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An Experiment with the Project Method:
Investigating Structured-Choice Learning in a STEAM Lab

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ABSTRACT

An Experiment with the Project Method: Investigating Structured-Choice Learning in a STEAM Lab

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Researchers and educators have argued that productive learning may occur when young people have freedom to organize their activity based on their own interests and concerns. Schools increasingly provide “makerspaces” that allow students to design and build objects and technical devices of their choosing, and researchers have developed in-school programs that provide students with a set of curated options among technology, engineering and design activities. Little is known empirically, however, about such environments: how young people learn when given the ability to decide and organize their activity, how districts establish and sustain choice-based environments, and how teachers organize and support them. In this dissertation, I explore these questions through an investigation of the STEAM Lab at Eagle Lake Middle School. During the 1920’s and 1930’s, the district became internationally recognized for its innovations, which included a substantial program of social and creative activities that provided opportunities for student choice and creative expression. Modern-day district leaders, seeing themselves as heirs to this tradition, undertook an experiment with the provision of choice to students. These innovations were a source of tension a century ago, and similar concerns echoed in the district today.

The experiment with *structured choice* in the STEAM Lab at Eagle Lake is the focus of this dissertation. As an overall conceptual framework, I describe a conflict between *scientific essentialist* and *humanistic* conceptions of teaching and learning. I show that these *instructional* *logics*, which had come into conflict historically at Eagle Lake, were being contested by modern-day teachers and administrators. Drawing on 6 months of ethnography in the STEAM Lab, I describe the student learning process under conditions of structured choice, using grounded theoretical methods to develop a process model I call *constructive interaction*. I then present the case of a 7th grader named Kira. Troubled in school, Kira found a home in the STEAM Lab, acquiring sophisticated technical skills, becoming a skilled instructor for her peers, and discovering a potential future identity as a creative professional. I show that Kira was ultimately harmed, however, by Eagle Lake's struggle to reconcile the competing instructional logics in the STEAM Lab through an assessment and grading rubric. I discuss alternative options for documenting student achievement in the STEAM Lab. This work may provide guidance for schools and districts seeking an appropriate balance of interests as they develop learning environments that provide increased freedom and choice to young people.

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Table of Contents

List of Figures

List of Tables

CHAPTER 1

Introduction

Overview of the Dissertation

The freedom, interests and goals of young people are, at most, ancillary considerations in the design of school-based learning environments (Cook-Sather, 2002; Murphy, 2016; Illich, 1971; Herndon, 1968; Goodman, 1962). Theorists have argued, however, that young people have a right to be heard, respected and included in discourse and decisionmaking about their learning (Rudduck & Flutter, 2004; Cook-Sather, 2006; Mitra, 2004; Fielding, 2001). Researchers and educators have made an additional claim: that productive learning may occur when young people have the ability to organize their activity based on their own interests and concerns (Ito et al., 2013; Stevens et al., 2016, 2018; Stevens, 2011; Barron, 2006; Goyal, 2016; Falk & Dierking, 2002; Godin, 2012; Laplante, 2013; Robinson, 2006; Draeger & Wilson, 2016; Montoy-Wilson, 2016; Anderson, 2016; Lillard, 2016; Pink, 2011; Kilpatrick, 1918). These ideas have started to take root in schools, as teachers set aside time for "genius hour" and "passion projects" that allow students to research topics of interest to them (Juliani, 2014; Krebs & Zvi, 2015). Schools increasingly provide "makerspaces" that often allow students the ability to design and build objects and technical devices of their choosing (Peppler, Halverson & Kafai, 2016; Halverson & Sheridan, 2014). Researchers have developed in-school programs that provide students with the ability to choose from a set of challenging activities and creative tools and to make moment-to-moment decisions about how to use their time (Stevens et al., 2018).

Little is known empirically, however, about these in-school environments that provide students with a measure of freedom and choice (for exceptions, see Ramey, 2017; Penney, 2016). Within the learning sciences, research has focused on a relatively narrow band of "inquiry" practices, in which a teacher presents students with a phenomenon and gives them some latitude to pose questions, collect data, and construct arguments (National Research Council, 2000; Kuhn, Black, Keselman & Kaplan 2000; Sandoval & Reiser, 2004). Where ambitious principles of freedom have been enacted, such as at the British school Summerhill (Neill, 1960, 1969), students were empowered at the level of school governance, but pedagogical practice in the classroom continued to follow a program of teacher-led instruction in traditional school subjects (Hemmings, 1973). Middle and high schools often provide students with some choice over the classes they take, but these "electives"—in which a student can choose to take, e.g., coding, art, auto shop or drama—rarely involve an activity structure in which students may decide what to do from one moment to the next. Only a scattering of private schools now offer students moment-to-moment choice (Goyal, 2016). Research on Montessori education, the most well-known example of choice-based learning, remains sparse, and the literature on Montessori learning that does exist is primarily evaluative and outcome-based rather than observational and ethnographic (see Lillard, 2016, for a review). This gap in practice and literature invites the question: *how do young people learn when given the ability to choose and organize their activity?*

At the same time, learning cannot be separated from its cultural, organizational and institutional context (Cole, 1996; Cole & Packer, 2016; Lemke et al., 2015). How could an environment of increased moment-to-moment choice come into being? The provision of freedom and choice in school conflicts with commonly held beliefs and values associated with formal education; the organization of formal instruction starts with the principle that adults will tell young people what to do and what to know (Illich, 1971). School acculturates the young (Henry, 1963; Bagley, 1939). Accordingly, a movement toward increased freedom for young people immediately raises one foundational dilemma, with the independence and creative expression of students conflicting with the need for guidance, control, and disciplinary instruction by the teacher and the school (Egan, 1997). A second dilemma involves the measurement of student "achievement." School and district leaders are accountable for scores on standardized tests (Yeomans, 1921), but the quantitative measurement of "personal qualities" such as resilience, teamwork, and creativity that may develop during choice-based activity is difficult (Duckworth & Yeager, 2015) or perhaps impossible (Holmes, 1912: 52). In light of these dilemmas, *how would a district establish and sustain an environment that provides students with freedom and choice?*

While theorists and policymakers navigate a world of abstract principles, and administrators concern themselves with the allocation of resources and time, the teacher must negotiate the moment-to-moment challenges that emerge as students are given more freedom and choice in the classroom. No body of knowledge or training converges on a single best method of instruction in school (Cohen, 2011), and the establishment of a choice-based learning environment raises complicated questions of practice with no clear answers. Accordingly, the third research question explored in this study is *how does a teacher organize and support an environment of freedom and choice?*

In this dissertation, I explore these 3 questions through a qualitative single-case study of the "STEAM Lab" at Eagle Lake Middle School.[1] During the period of this research (2016-2019), the professional staff at Eagle Lake undertook an experiment with the provision of choice to students enrolled in the "Tech21" class in the STEAM Lab.[2] I interviewed the teachers and school and district leaders who were involved in establishing this program and similar initiatives at Eagle Lake, data that is presented and discussed in Chapter 2. I show that Eagle Lake teachers and administrators were engaged in an ongoing and highly contested effort to balance competing goals: the documentation and scientific measurement of student progress toward academic goals, and the development of 21st century skills or "personal qualities" (Duckworth & Yeager, 2015) through the provision of environments that afforded freedom and choice. Chapter 3 develops a model of learning processes in the choice-based STEAM Lab, based on 6 months of participant observation, which I call *constructive interaction.* In this chapter, I present a series of ethnographic vignettes that demonstrate the personal development and growth that teachers and administrators sought. In Chapter 4, I show that the district's effort to find a workable compromise between the competing goals failed in the case of a student named Kira, whose dramatic and powerful learning experience in the STEAM Lab ultimately took a surprising turn that highlights the dilemmas faced by the professionals at Eagle Lake. Finally, in the closing chapter I draw on a recommendation from Cuban (2001) and propose an alternative compromise:

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[1] Eagle Lake is a pseudonym, and identifying details associated with the school and the community have been changed. These details include citations to published and unpublished research about Eagle Lake; I have changed the names of authors and slightly altered the publication titles and quotations to preserve the school's anonymity.
[2] STEAM stands for science, technology, engineering, art/design, and mathematics, although the term was used in the district to describe hands-on, maker-oriented design, engineering, and technology activities. Disciplinary science and mathematics were generally not present, which gave rise to a tension I describe in Chapter 2.

a new documentation and assessment tool envisioned by Kira and Mr. Jacobson that may improve the learning experience for students like Kira.

Eagle Lake represents only a single "case" (Ragin & Becker, 1992) of an implementation of structured-choice learning. A reasonable goal for the qualitative researcher is to establish a basis for considering a social phenomenon as "a process, the same no matter where it occurs, in which variations in conditions create variations in results" (Becker, 1990: 240). This work may provide, then, a starting point or comparative example for schools and districts seeking a "reasoned balance of interests" (Kridel & Bullough Jr., 2007: 32) as they develop learning environments that provide increased freedom and choice to young people in school.

Eagle Lake's History

A century ago, Eagle Lake was one of a small number of schools and districts around the United States that were closely tied to the Progressive Education Association (see Graham, 1967). Eagle Lake's nationally-recognized reforms during the 1920s and 1930s were the subject of two dissertations (Talcott, 1962; Schumann, 1970) as well as a memoir by the superintendent of that period, Alexander McHenry (McHenry & Marbury, 1963). Interviews with current district leaders in Eagle Lake revealed that they believed that this "progressive" history, identity and philosophy continued to guide their practices.[3] The word "progressive" circulated and was contested in the community and among teachers and administrators; an assistant superintendent spoke of "fighting for the soul of progressive education" against skeptical board members and

[3] "Progressive" was first used by Henderson (1896) to refer to what was then called "new" or "child-centered" education (Staring, 2018). In the ensuing decades, "progressive" came to serve as a shorthand for a broad and sometimes contradictory set of reform principles, making it an awkward analytic construct. Eagle Lake staff had diverse associations with the term. I use it in this dissertation exclusively in a historical sense to refer to the "many-sided" (Cremin, 1961) reform movement of the early 20th century.

parents (Interview, November 21, 2016). References by the professional staff to "our history" were common, and the superintendent reported that she kept a copy of McHenry's memoir on her desk and consulted it frequently (Interviews, 2016).

Because the district's past was very much present its modern-day practices, cited as a model and invoked as a source of legitimacy, I conducted extensive research into this history. I discovered that McHenry and Eagle Lake had played an important role in the early 20th century progressive education movement. A leading American theorist of the era, William H. Kilpatrick, had written about the district, assessing McHenry's innovations as "well-nigh unique in American public education" (1926). McHenry served in a leadership role in national and international progressive organizations, published in key journals, and established a publications division that promoted Eagle Lake's methods and distributed curricular materials across the country (Talcott, 1962). I also discovered that McHenry's tenure had been highly controversial. Parents' concerns over his methods escalated into a full-blown challenge to his superintendency, with the mounting of an opposition slate in the school board election of 1933 (Schumann, 1970; Talcott, 1962). These local tensions took place amidst intense debates about educational reforms that occurred across the United States during the early and middle 20th century (Kliebard, 1986; Cremin, 1961; Ravitch, 1983).

McHenry was quietly replaced in 1943, and the district's rollback of his reforms anticipated a broader rejection of a certain line of reform practices in the U.S. during the 1940s and 1950s (Zilversmit, 1996; Cremin, 1961; Graham, 1967; Talcott, 1962). In the decades that followed, Eagle Lake increasingly came to resemble schools in the surrounding communities (Talcott, 1962; Interviews, 2016). Like districts across the United States, during the Cold War Eagle Lake refocused its efforts on traditional instruction, especially in math and science

(Zilversmit, 1996). By the 1990s, the word "progressive" did not appear in a brochure that the school published to describe its philosophy. At the time of this study, the superintendent consciously avoided the term in her public statements, noting that this absence was deliberate, calling the term "more polarizing than bridging" (Interview, 2016). Longstanding "experiential learning" activities at Eagle Lake such as a "Pioneer Room" (in which students adopted the roles of early American settlers) and a Civil War re-enactment remained from this earlier time and were often cited in response to questions about what "progressive education" meant in modern-day practice (Interviews, 2016-17), but Eagle Lake's principal said that "there is more traditional here than folks would claim" and a district administrator described Eagle Lake as "resting on our 'progressive' laurels" (Interviews, 2016).

To study Eagle Lake and its evolution is to open a gateway to the theories and debates of a distant chapter in educational history, where the core ideas, oppositions, and tensions that still shape American educational thought were first theorized. As an overall framing for this dissertation, I will sketch three perspectives on the goals of education, connecting these to Eagle Lake's historical practices. Building on distinctions and taxonomies developed by educational historians and philosophers (e.g., Kliebard, 1986; Labaree, 1997; Egan, 1997), I first describe what I will call *essentialist* and *scientific* perspectives. A blend of these principles, which I will call *scientific essentialism*, came to guide instructional practice in most American schools, including Eagle Lake, during the 20th century (Cuban, 1983; Cremin, 1961). I then discuss critiques of scientific essentialist practice, developed largely by scholars and commentators from outside the world of professional education. Within these "outsider" critiques, I locate arguments for an alternative: *humanistic* education, involving activity organized around the freedom, interests, goals, and concerns of the learner (Stevens, 2011) and dedicated to the development of the human personality. These principles were integral to Eagle Lake's decades-old reforms as well as the modern-day design of the STEAM Lab class that is the focus of this dissertation (Interviews, 2016). In the empirical chapters that follow, I will describe the tensions between humanistic and scientific essentialist views that emerged, and I discuss the student experience in the STEAM Lab using, in part, humanistic theoretical lenses developed during the early progressive period.

Perspectives on teaching and learning

> We're accountable for standards. We want good learning going on. Standards represent good learning in a lot of ways … it gives us a path to follow, a skeleton to guide us …What are the standards we're trying to achieve? What do we, in education, believe is important for these students to know? *Mrs. Carman, principal at Eagle Lake Elementary*

> There's a 'data monster' in the community. Quantitative data … has to guide how we are looking at programs that we've implemented, and whether or not they're successful. But sometimes there's an over-reliance on this quantitative data, and it becomes this sole driver to some parents. I mean, you go to some board meetings and it's, like, such a huge concern. *Mr. Swanson, assistant principal at Eagle Lake Elementary*

> Kids need to get strengths and to build life skills, to build the four C skills, the communication, collaboration, critical thinking, and creativity, and then on the flip side, and these all relate, self-motivation, and resilience, and moving forward. *Mr. Jacobson, STEAM Lab teacher at Eagle Lake Middle School*

What is school "for"? Each of these observations by the professional staff at Eagle Lake represents a different view about the fundamental purposes of education. Mrs. Carman's advocacy for "standards" highlights a view of the importance of transmitting cultural discoveries and achievements in science, mathematics, and the humanities to the next generation. Mr. Swanson's account of a "data monster" characterizes parents' attention to Eagle Lake's program of rigorous assessment, in which the progress of each individual learner is measured through tests. Mr. Jacobson's "strengths" and "life skills" point to the development of the human personality and the formation of character.[4] Eagle Lake's design for a STEAM Lab class based on principles of student freedom and personal development produced a series of tensions among these views, which will be explored in the chapters that follow. Cuban (2001) describes the *dilemmas* of education:

> ill-defined, ambiguous, complicated, interconnected situations packed with potential conflict [that] arise when people compete for limited resources … hold conflicting values … and wrestle with diverse expectations held by others about what practitioners should be doing. (10)

What was at the root of the dilemmas at Eagle Lake? What were the different visions of teaching and learning that came into conflict in and around the STEAM Lab? Here, I will describe *essentialist, scientific,* and *humanistic* perspectives that will, in part, guide the analysis in the empirical chapters that follow.

The essentialist perspective

The common understanding of learning in school as externally-directed and compulsory extends to the earliest systems of formal education in Western societies (Cubberley, 1919)[5] and served as the template for mass instruction in the modern era. In the United States, a panel of scholars and educators known as the Committee of Ten convened in 1892 to draw up a list of subjects, derived from academic disciplines, that would be taught to all students "in the same

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[4] These are the three perspectives discussed in this chapter. Scholars and practitioners have also conceptualized school as a place to prepare young people for the responsibilities of democratic citizenship (e.g., Dewey, 1916; Rudduck & Flutter, 2004; Cook-Sather, 2006; Mitra, 2004; Fielding, 2001), create a more just and equitable society (e.g., Counts, 1932; Rugg, 1931, 1933, 1936; Freire, 1970; Bang & Vossoughi, 2016), train people for jobs (e.g., Della Vos, 1876; Snedden, 1921; Gordon, 2003), develop the national economy (e.g., National Commission on Excellence in Education, 1983; National Science & Technology Council, 2018), or get the edge on other people for scarce positions in college and the high-salaried professions (e.g., Labaree, 1997; Markovitz, 2019; Packer, 2019). Kliebard (1986), Cremin (1961), Egan (1997), and Labaree (1997) have developed formal or informal typologies of various views on school's purposes.

[5] Although evidence is scant, it is likely that this conceptualization of school extends to ancient human civilizations. For example, archaeologists have discovered a writing exercise from a school in Mesopotamia in which a student vividly describes a strict regimen of script copying and corporal punishment (Kriwaczek, 2014).

way and to the same extent to every pupil" (National Education Association, 1893: 17). Teachers were to assign and evaluate work, following rules and procedures established by school and district leaders. Students would move through a structured curriculum in a synchronized progression (Burk, 1913). Bagley (1939) defined *essentialism* as a position that

> emphasizes the basic significance of the accumulated experience of the race, and affirms the chief concern of education to be the transmission to each generation of the most important lessons that have come out of this experience … (326)

Eagle Lake, despite its reputation as a "progressive" school, played a role in the development of the essentialist program in the United States during the 1920's. The superintendent Alexander McHenry and his staff developed a set of "common essentials"[6]—learning objectives in reading, writing, mathematics, social studies, and science—along with elaborately designed curricular materials that they distributed to educators nationally (Talcott, 1962; McHenry & Marbury, 1963). In McHenry's view, "children needed systematic instruction in the common essentials and … the school should provide specific time each day for such study and drill" (Talcott, 1962).

The term "essentialism" faded from policy discourse by midcentury, as did its harsher associations with the recitation method and drill-based practice, but the postwar period saw an ever-increasing focus on core academic subjects, especially in mathematics and science, that has continued into the present day (Zilversmit, 1996; Cuban, 1983). Organization of instruction around "standards" represents the fundamentals of the essentialist paradigm: disciplinary learning objectives organized in a grade-level progression. Like most American schools, Eagle Lake designs its instructional program around these broadly accepted standards documents. The Common Core State Standards for reading and mathematics (National Governors Association,

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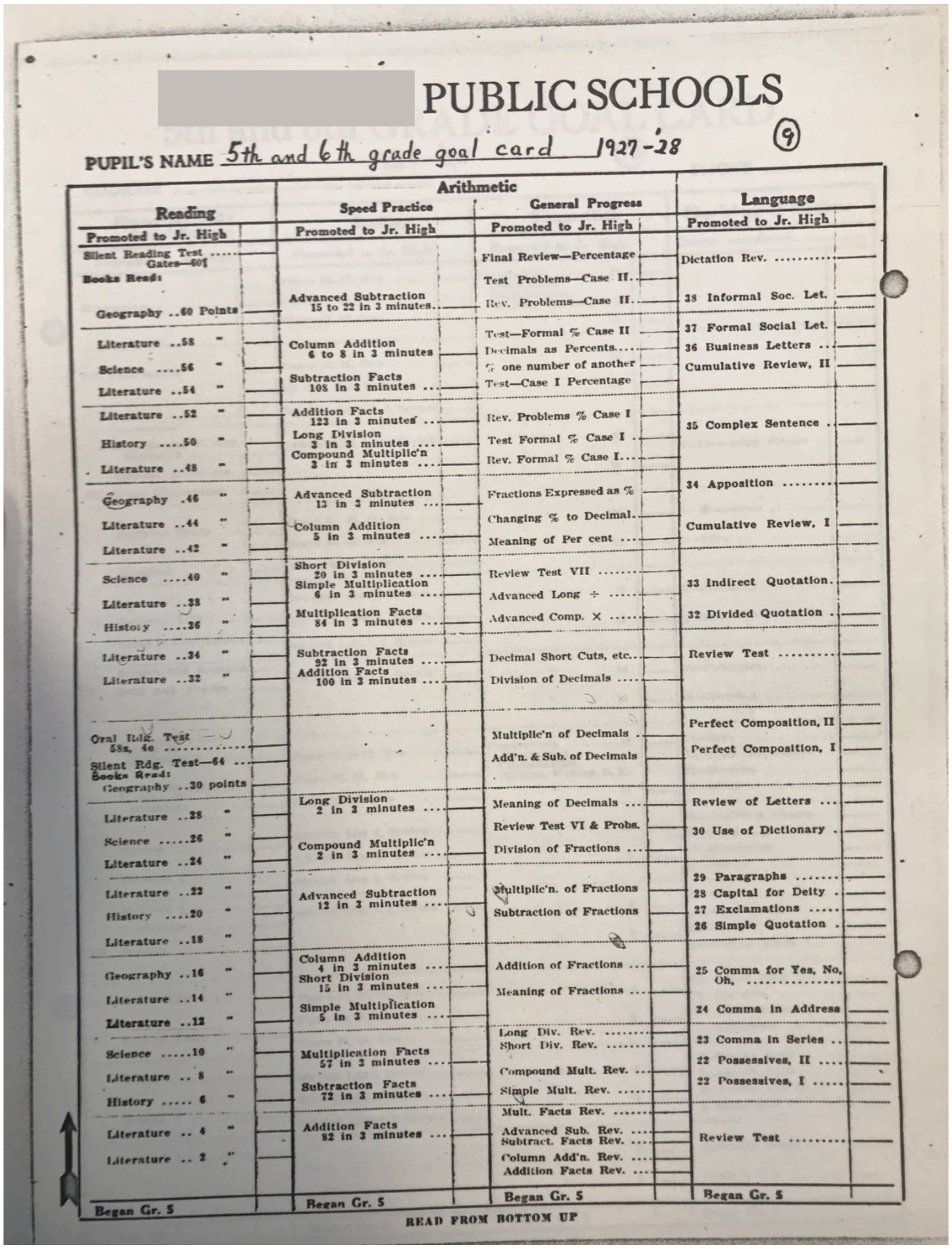
[6] Bagley may have been aware of McHenry's "common essentials," a term McHenry used in published research during the 1920's. Bagley (1939: 326) credits the term *essentialist,* however, to Demiashkevich (1935).

2010) "outline what a student should know and be able to do at the end of each grade" (corestandards.org, n.d.). Current science content standards emphasize "disciplinary core ideas" (NGSS Lead States, 2013). In sum, the *essentialist* perspective prioritizes disciplinary knowledge, the organization of learning by subject area, and the systematic transmission of the Western cultural and scientific heritage, all within a framework of compulsory instruction.

The scientific perspective

The *scientific* perspective dates at least to the early progressive period and emphasizes quantitative measurement to assess "intelligence" (Kelly, 1914; Binet & Simon, 1916; Terman, 1916) and to monitor student progress within a defined educational program. From the first decades of the 20th century into modern times, school administrators, policymakers, and parents have attended closely to student "progress" through the analysis of data produced by the administration of standardized tests, seeking constant improvement in student performance (Kelly, 1914; Yeomans, 1921: 4). Student test results that meet or exceed the school's expectations for performance at a particular grade level have come to be interchangeable with the terms "learning" and "achievement" in school. The scientific position is closely connected to the essentialist view: educators require students to produce quantifiable evidence that they possess the requisite disciplinary knowledge from the essentialist program. This framework of what I will call *scientific essentialism*—compulsory mass instruction in an age-graded curriculum, monitored by tests that assess individual student progress—came to form the common cultural understanding of what it meant to learn in school, and with important exceptions, the model has resisted sporadic efforts at systemic change and continued into the present day (Tyack & Tobin, 1994; Cuban, 1993; Cohen, 1988).

The tight connection between essentialist theory and principles of scientific measurement may be seen in Eagle Lake's own history. The superintendent McHenry and his staff designed not only elaborate instructional materials in the "common essentials" but rigorous assessments intended to ensure that students had become fluent in certain subject matter before advancing, anticipating a modern-day movement toward "mastery learning" (Guskey, 2010). Teachers at Eagle Lake described "an unending succession of mimeographed instruction sheets, exercise sheets, practice tests, final tests, and reviews" during the common essentials instructional time (Talcott, 1962). A key element in this process was the "goal card" (*see* Figure 1).



[redacted] PUBLIC SCHOOLS

PUPIL'S NAME 5th and 6th grade goal card 1927-'28 (9)

Reading	Arithmetic: Speed Practice	Arithmetic: General Progress	Language
Promoted to Jr. High	Promoted to Jr. High	Promoted to Jr. High	Promoted to Jr. High
Silent Reading Test Gates—60↑ Books Read: Geography ..60 Points	Advanced Subtraction 15 to 22 in 3 minutes	Final Review—Percentage Test Problems—Case II Rev. Problems—Case II	Dictation Rev. 38 Informal Soc. Let.
Literature ..58 " Science ....56 " Literature ..54 "	Column Addition 6 to 8 in 3 minutes Subtraction Facts 108 in 3 minutes	Test—Formal % Case II Decimals as Percents % one number of another Test—Case I Percentage	37 Formal Social Let. 36 Business Letters Cumulative Review, II
Literature ..52 " History ....50 " Literature ..48 "	Addition Facts 123 in 3 minutes Long Division 3 in 3 minutes Compound Multiplic'n 3 in 3 minutes	Rev. Problems % Case I Test Formal % Case I Rev. Formal % Case I	35 Complex Sentence
Geography .46 " Literature ..44 " Literature ..42 "	Advanced Subtraction 13 in 3 minutes Column Addition 5 in 3 minutes	Fractions Expressed as % Changing % to Decimal Meaning of Per cent	34 Apposition Cumulative Review, I
Science ....40 " Literature ..38 " History ....36 "	Short Division 20 in 3 minutes Simple Multiplication 6 in 3 minutes Multiplication Facts 84 in 3 minutes	Review Test VII Advanced Long ÷ Advanced Comp. ×	33 Indirect Quotation 32 Divided Quotation
Literature ..34 " Literature ..32 "	Subtraction Facts 92 in 3 minutes Addition Facts 100 in 3 minutes	Decimal Short Cuts, etc. Division of Decimals	Review Test
Oral Rdg. Test 58s, 4e Silent Rdg. Test—64 Books Read: Geography ..30 points		Multiplic'n of Decimals Add'n. & Sub. of Decimals	Perfect Composition, II Perfect Composition, I
Literature ..28 " Science .....26 " Literature ..24 "	Long Division 2 in 3 minutes Compound Multiplic'n 2 in 3 minutes	Meaning of Decimals Review Test VI & Probs. Division of Fractions	Review of Letters 30 Use of Dictionary
Literature ..22 " History ....20 " Literature ..18 "	Advanced Subtraction 12 in 3 minutes	Multiplic'n. of Fractions Subtraction of Fractions	29 Paragraphs 28 Capital for Deity 27 Exclamations 26 Simple Quotation
Geography ..16 " Literature ..14 " Literature ..12 "	Column Addition 4 in 3 minutes Short Division 15 in 3 minutes Simple Multiplication 5 in 3 minutes	Addition of Fractions Meaning of Fractions	25 Comma for Yes, No, Oh, 24 Comma in Address
Science .....10 " Literature .. 8 " History ..... 6 "	Multiplication Facts 57 in 3 minutes Subtraction Facts 72 in 3 minutes	Long Div. Rev. Short Div. Rev. Compound Mult. Rev. Simple Mult. Rev.	23 Comma in Series 22 Possessives, II 22 Possessives, I
Literature .. 4 " Literature .. 2 "	Addition Facts 82 in 3 minutes	Mult. Facts Rev. Advanced Sub. Rev. Subtract. Facts Rev. Column Add'n. Rev. Addition Facts Rev.	Review Test
Began Gr. 5	Began Gr. 5	Began Gr. 5	Began Gr. 5

READ FROM BOTTOM UP

Figure 1. A "goal card", used by Eagle Lake in the 1920's to organize individual self-instruction in disciplinary school subjects.

McHenry had developed the goal card system out of the research he had conducted under the supervision of Isaac Black, a theorist who devised a program of self-directed, self-instructive materials that allowed students to work at their own pace while being subject to ongoing assessment by school authorities (McHenry & Marbury, 1963; Talcott, 1962; Black, 1913).

McHenry's interest in measurement also derived from his sense of accountability to the families in the wealthy community of Eagle Lake, who demanded that the school prepare students for the entrance exams of competitive boarding schools of the East (Talcott, 1962). Parents collected and shared detailed statistics comparing the performance of Eagle Lake students at the local high school to those of other schools in the area (Schumann, 1970), just as modern-day Eagle Lake parents would do a century later (Interviews, 2016).

"Outsider" critiques of scientific essentialism

> One had to cram all this stuff into one's mind. This coercion had such a deterring effect that, after I had passed the final examination, I found the consideration of any problem distasteful to me for an entire year. …
>
> It is, in fact, nothing short of a miracle that the modern methods of instruction have not yet entirely strangled the holy curiosity of inquiry; for this delicate little plant, aside from stimulation, stands mainly in need of freedom. Without this it goes to wrack and ruin, without fail.
>
> *Albert Einstein* (1949: 10)

Illich (1971) argued that research on instructional practice seeks merely to "optimize the efficiency of an inherited framework—a framework which is itself never questioned" (70). The framework to which he referred is scientific essentialism, defined here as compulsory mass instruction in an age-graded program of disciplinary knowledge, monitored by tests that assess individual student progress. Contrary to Illich's assertion, however, commentators from a range of disciplinary perspectives have developed a series of critiques of the scientific essentialist framework. In what follows, I identify four lines of critique in this literature: school as a site of *coercion and control, lockstep instruction, deficit production,* and *normalizing judgment.*

Coercion and control

Dewey (1938) saw school as demanding docility and obedience; in his final published work (1952), he lamented the persistence in classrooms of what he called "the fundamental authoritarianism of the old education". This view of school has a long provenance; Dickens (1848), for example, saw "a forcing apparatus, incessantly at work" as the British schools of his day moved students through grade-level progressions (142). This coercive dimension of school is a consistent theme among the "outsider" critics, who understand school, first and foremost, as a place where professional educators tell younger people what to do. Illich (1971) defines school as an "age-specific, teacher-related process requiring full-time attendance at an obligatory curriculum" (25-26) and argues that defining a person as a student

> permits the teacher to exercise a kind of power over their persons which is much less limited by constitutional … restrictions than the power wielded by the guardians of other social enclaves. Their chronological age disqualifies children from safeguards which are routine for adults ... (15)

Adults conceive, organize, and direct instruction, and young people are required to participate; schools provide spaces where administrators and teachers can efficiently supervise, discipline, and control students (Foucault, 1977: 147). Herndon (1968), in a memoir of teaching in an urban school, saw the classroom as a place for

> being bottled up for seven hours a day in a place where you decide nothing, having your success or failure depend, a hundred times a day, on the plan, invention, and whim of someone else, being put in a position where most of your real desires are not only ignored but actively penalized. (127)

The experience of powerlessness under the authority of school comes through vividly in the stories reported by the relatively small number of researchers who have attended empirically to student perceptions. Mergendoller and Packer (1985) reported that students viewed school's rules as arbitrary and "an affront to their evolving status as independent young men and women" (591). A British high school student reported:

> I must admit to my share of graffiti on the science lab gas taps as sixty students have gathered (and have spent half an hour being herded) around a desk to watch water boil. If the teacher had simply recognized that we were people with brains she would have realized that we all knew what water

> looks like while boiling. She could have said 'when water boils …' and got on with the lesson, instead of driving me to the frustration it takes to write 'Get me out of this f-ing dump' in pencil, not even caring about the possibility of her wrath if caught.
>
> *Miriam,* quoted in Burke & Grosvenor (2003: 76)

Miriam's plea to "get me out" is echoed by other studies of student perceptions. Blishen (1969), reviewing an archive of student reports on their experiences in school, concluded that young people were

> begging that they be allowed to *get out* of the dead air of the classroom—to be freed from that sterile and cramped learning situation in which the teacher, the text book, and the examination-dominated syllabus have decided what should be learnt, and how it should be learnt, and that virtually everything should be presented as a hurried intellectual abstraction. (1969: 55; italics in original)

Goodman (1964) argued that creative work was impossible in such an environment, in which curricular goals are determined externally and assigned under coercion. He saw

> far too much bother about getting children to learn a set curriculum and to meet certain standards. Not that children are incapable of learning or do not want to learn; on the contrary, all the evidence is that even average children are capable and desirous of much more intellectual stimulation than they ever get in school, and with bright children this is astoundingly the case. Teachers and adults in general have a responsibility to press, provide means, offer the new, and be available. But this is entirely different from assigning lessons and demanding performance, as if children did not have natural curiosity and wonder.

These perspectives, ironically, refer to school authority at its most benign: the everyday routines of attending class, reading textbooks, doing assignments, participating in science labs, and so on. School is, of course, also a site for "disciplining" students (Kohn, 2006). Many schools impose so-called "zero tolerance" policies for behavioral infractions (Skiba & Peterson, 1999). Studies show that these policies can lead to harshly punitive practices which are directed disproportionately at students of color (e.g., Welch & Payne, 2010; Monroe, 2005; Roque & Paternoster, 2011), although Kohl (1969) suggests that

> there is the same obsession with power and discipline everywhere; for most American children there is essentially one public school system in the United States and it is authoritarian and oppressive. Students everywhere are deprived of the right to make choices concerning their own destinities. (2)

Lockstep instruction

Herndon (1971) argued that "the fundamental act of the American public schools is to deal with children in groups … once [school] has a group of children of any age, it decides what those children will be expected to do, and then the teacher, as representative of the school, tells the children all at once". Becker (1972) observed that schools "process students in batches, treating them as if each were the prototypical normal student for whom they constructed the curriculum" (88). Because no students are precisely "average," all students are by definition out of alignment with some externally calculated norm (Rose, 2016; Fendler & Muzaffar, 2008; Burk, 1913). Curricular progressions are based on the projected growth of the prototypical student and then applied to all students. Burk (1913), however, described the notion of the average student as "an algebraic myth born of inanimate figures and an addled pedagogy" (7) and criticized the notion of organizing school in "lockstep" around this norm:

> Could any system be more stupid in its assumptions, more impossible in its conditions, and more juggernautic in its operation? Every one of its premises is palpably false; every one of its requirements is impossible and every one of its effects is inefficient and brutal. Nevertheless this system has endured and has been endured for centuries. (Burk, 1913: 12)

Dewey suggested that school fails "to take into account adaptation to the needs and capacities of individuals" (1938: 27), not recognizing "the intensely distinctive beings that we are acquainted with out of school, in the home, the family, on the playground, and in the neighborhood" (1915: 33). Goodman (1964) saw "a uniformity of conception, from the universities down, that cannot possibly suit the multitude of dispositions and conditions", paying "little attention to individual pace, rhythm or choice, and none whatever to discovery of identity or devotion to intellectual goals".

Recognition and critique of the batch processing model of school has become, in recent years, a cliché of popular commentary on education, and motivates "educational technology" that claim to "personalize" the learning experience for students (Watters, 2017). Some propose to vary the modality through which the same curriculum is delivered, warranted by an assertion that students have different "learning styles" (Fleming & Baume, 2006; Claxton & Ralston, 1978; but see Willingham et al., 2015). Other scholars propose "differentiated" instruction (Tomlinson & McTighe, 2006; Tomlinson, 2014; Subban, 2006). Although these approaches have been widely accepted—many schools now employ "differentiation specialists" as full-time staff, and "learning styles" has transcended its empirically dubious origins to become an educational catchphrase—they represent only incremental change on the margins of the school system, varying only the pace at which a standard curriculum is delivered to all students. The basis for such differentiation is not the interests, goals, and concerns of the learner (Stevens, 2020; Stevens, 2011), but their scores on "formative assessments" that produce "differences" based on "ability" (Terwel, 2006).

Systematic deficit production

School defines a distance between the student's current knowledge and certain material to be taught (Ranciere, 1991). Once this distance has been asserted, the existence of the gap positions all students as yet-to-complete the progression that the school has defined. Teachers then construct and deliver an explication of this material (Freire [1970] called it a "narration") to guide the student from ignorance to expertise (Ranciere, 1991: 4-8). A regime of tests and assignments then assesses students' ability to accurately reproduce the narrated explanations. Education professionals assume and expect that student performance on these assessments will follow a normal distribution and that this bell curve represents the natural order of things (Fendler & Muzaffar, 2008: 64).

Within the "outsider" critique, however, this inability of certain students to achieve learning objectives is understood as an intentional and inevitable construction of the teacher and school. Having defined an objective that not all students will be able to meet—if they did, the objective would be considered too easy (Kohn, 2019)—school as an institution necessarily produces "failure" (Varenne & McDermott, 1999; Fendler & Muzaffar, 2008; Becker, 1972). Systems of measurement and assessment produce classifications such as "learning disabled"; these constructs lead to organizational structures designed to raise achievement for students who are so classified; and finally certain students must be recruited—attached to these labels—in order to fill the categories (McDermott, 1996; Mehan, 1991). The constructs of "learning deficits" and "learning disabilities," however well-intentioned their application, are in this view also outcomes necessarily produced by the technical and administrative operating core of the school.

Normalizing judgment

Teachers provide students with explanations, encouragement, and feedback, but also calculate scores and assign grades. Students are assessed using norm-referenced examinations in a process of what Foucault (1977) called "normalizing judgment." In the "outsider" view, the interaction of instruction, coaching, and assessment is seen to have consequences that are detrimental to learning (Illich, 1971):

> The safeguards of individual freedom are all canceled in the dealings of a teacher with his pupil. When the schoolteacher fuses in his person the functions of judge, ideologue, and doctor, the fundamental style of society is perverted by the very process which should prepare for life.

Imperfect performance on assessments comes to signify personal or moral failure (Kohn, 2000; Illich, 1971), which students are desperate to avoid. The educator John Holt (1964), reflecting on his experience as an elementary school teacher, writes that he and his colleagues

> saw correctly enough that the reason so many children in our classes learned so little was that they used such bad thinking and problem-solving strategies. What I did not see until later was that we, our classroom, our position as teachers, which is to say, givers of orders, judges, graders, were the source of these children's strategies. We, and not math, or reading, or spelling, or history, were the problem that the children had designed their strategies to cope with.

Holt's claim is supported by a finding from classroom ethnographies: students spend much of their time and energy in school simply trying not to be caught not knowing something (McDermott & Raley, 2016).

This critique of the power balance in the classroom as corruptive finds support from Piaget (1966), who drew a sharp distinction between learning through "educational transmissions" and learning through "social or interpersonal interactions" (1966: 262). Cole (1996), surveying Piaget's late work, concludes:

> Piaget was skeptical of schooling's development-enhancing properties. He argued that the asymmetrical power relations of teacher and student created an imbalance because the pressure to accommodate to teachers' views far outweighed the pressure for assimilation of instruction to the child's already existing schemas. The result was learning of a superficial kind that was unlikely to create fundamental cognitive change. (87)

In an invited commentary on Article 26 of the Universal Declaration of Human Rights (United Nations, 1948), which called for education to be "directed to the full development of the personality", Piaget (1948/1973) argued that "personality development really requires a social milieu based on collaboration [among teachers and students] and not on submissiveness" (92).[7]

Summary of the "outsider" critique

Few would contest the general observation that teachers and schools decide what, how, and when kids learn. This brief survey of an "outsider" critique, however, has produced an alternative interpretation of this widely accepted premise: an image of school as an institution

[7] Piaget's Article 26 commentary refers to personality development in a broad sense. His age-linked view of particular developmental processes has been questioned by theorists and researchers (e.g., Stevens, 2020; Egan, 1997; Matusov & Hayes, 2000).

organized around the doctrine of coercive mass instruction. In the "outsider" view, the common approach to education induces—both by definition and in practice—weakness, subordination, and powerlessness on the part of the learner. Students are compelled to participate in a process that perpetually defines them as yet-to-complete a systematic course of instruction that another has created for them. Such a compulsory system actively discourages individuals from taking control of their own learning (Illich, 1971). It integrates the presentation and explication of content with the student's continuing compliance and participation, and connects learning to processes of institutional assessment and judgment (Freire, 1970; Ranciere, 1991). It defines an "average" performance standard and then assesses each student relative to that standard, meaning all students are automatically either ahead or behind (Fendler & Muzaffar, 2008; Burk, 1913). The assessment regime produces a spectrum of defined categories of achievement, into which students must be recruited (McDermott, 1996; Mehan, 1991). Although this perspective critiques the routine practices of school, many districts implement extreme disciplinary regimes that disproportionately affect the poor and students of color (Welch & Payne, 2010). Ultimately, the authority structure of school works against the full development of the human personality (Piaget, 1948/1973).

The humanistic perspective

The alternative to an educational philosophy that is externally-directed, compulsory, and focused on the acquisition of academic knowledge is one that is driven from within the individual, freely chosen, and organized to support the development of the human being (Dewey, 1902). This vision anchored the core principles of organizations and journals in the United States and England in the early 20th century that advocated what was variously called "new," "child-centered," or "progressive" education (Cremin, 1961; Graham, 1967; Brehony, 2004;

Howlett, 2017; Reese, 2001) and dates at least to Rousseau (1762). In this section, I will describe a *humanistic* educational philosophy, based on the freedom, interests, needs, goals, and social and personal development of the learner.[8] Humanistic education reflects "a deep-seated commitment to, and respect for … students as autonomous, self-directed people" (Beyer, 1997: 472).

"Freedom" was associated with "development" throughout early humanistic literature. The foundational document of the Progressive Education Association (1919) stated its aim as "the freest and fullest development of the individual." Kliebard (1986) uses "developmentalist" to refer to a line of theory that includes the perspectives described in this section. Although the emphasis on young people's freedom and interests declined after the height of the progressive period (Zilversmit, 1996), modern-day educators continue to advocate for the personal development of students. This development is asserted to include resilience, creativity, teamwork, leadership, self-direction, innovative adaptation, and problem-solving, sometimes collectively called 21st century skills (National Research Council, 2013), character (Heckman & Kautz, 2014), non-cognitive skills (Levin, 2013), or personal qualities (Duckworth & Yeager, 2015).

As described in the opening of this chapter, the Eagle Lake schools have a century-long association with humanistic educational practices that continues to this day (Interviews, 2016; Talcott, 1962; Schumann, 1970; McHenry & Marbury, 1963). During the 1910's, community

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[8] I draw *humanistic* from Rogers' (1951) *humanistic education*, in which students "take self-initiated action … are capable of intelligent choice and self-direction … are critical learners … have acquired knowledge … adapt flexibly … utilize all pertinent experience freely and creatively … cooperate effectively … [and] work … in terms of their own socialized purposes" (387–388, cited in Cornelius-White [2007]: 114). Kliebard's (1986) taxonomy uses "humanist" to refer to what I have defined here as "essentialist."

leaders sought to recruit a superintendent conversant with "child-centered" education (Talcott, 1962). The search committee chair called on the school board to "resist the temptation to conformity and conservatism and 'safety first' in general and get a school and school spirit which will meet the appraisal of a person like Dewey" (quoted in Talcott, 1962), and reached out to McHenry.[9] In promoting his candidacy, McHenry sought to emphasize his humanistic views, writing to the search committee in early 1919:

> We have built our schools in the past too much on children's *receptive* powers. … We must in the future build on *creative* powers, thereby generating dynamism, initiative, originality, and diversity – all the things that go to make the really live [person]. (quoted in McHenry & Marbury, 1963; italics added)

McHenry designed a "common essentials" program in the morning but in the afternoon offered "social and creative activities," including group problem solving, self-government activities, assemblies, music, rhythms, art, shop, supervised play, creative writing, clubs, festivals, pageants, bazaars, charity activities, field trips, and individual and class projects (Talcott, 1962; McHenry & Marbury, 1963). In his memoir (1963), McHenry reflected on his reforms at Eagle Lake during the 1920's, describing the "social and creative activities" as

> the vital, life giving part of the curriculum. They are the real education. Giving children a mastery of the three R's is important but it is mere training. Education involves drawing out the child himself. [*sic*]

McHenry's advocacy for student freedom during the social and creative activities segment of the school day, and in particular his use of the term *project,* reflected an emerging humanistic idea and revealed a foundational tension in cultural beliefs regarding the goals and

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[9] McHenry was known to local leaders through family connections (Schumann, 1970), although his memoir (1963) claims that Eagle Lake found him based only on his connection with Burk. During the 1890s, McHenry had attended a nearby elementary school closely associated with the forerunners of the progressive movement, and one of his parents, who was connected to Eagle Lake civic leaders, had served as managing editor of a reform educational journal (Schumann, 1970). Schumann's (1970) critical dissertation argues that community leaders in Eagle Lake never actually cared about innovative methods, were concerned principally with the advancement of their children into the elite prep schools, and sought a reform-minded superintendent principally out of an interest in being seen as fashionable and attracting wealthy people to settle in the community.

purposes of education. This tension could be seen clearly in a proposed change in the meaning of "project" proposed by the Teachers College professor William H. Kilpatrick and the sharp reactions he received from his colleagues. In 1918, Kilpatrick published a provocative argument for the centrality of student goals to the learning process (Tenenbaum, 1951). Kilpatrick's *The Project Method: The Use of the Purposeful Act in the Educative Process*, which circulated widely during the 1920s and 1930s, propelled him to worldwide fame (Kilpatrick, 1918, 1925; Beyer, 1997). A popular and respected professor of educational philosophy, Kilpatrick influenced thousands of teachers and administrators over his long teaching career (Tenenbaum, 1951).[10] Kilpatrick's use of the term *project method,* however, constituted a theoretical sleight of hand that drew bitter critiques from his colleagues as the article circulated in draft form (Knoll, 2012). Kilpatrick acknowledged in his published paper (1918: 4) that scholars and educators had long used the term *project* to describe practical, constructive, hands-on work designed by teachers and assigned to students to advance disciplinary educational goals (e.g., Woodward, 1887, 1890; Stimson, 1912; see Staring, 2018), but insisted on redefining *project* to mean "wholehearted purposeful activity" chosen by the student (4). Kilpatrick's "project" thus marked a separation from the essentialist program, and Kilpatrick would also have distinguished it from modern-day theories of "project-based learning" (e.g., Krajcik & Blumenfeld, 2006) that

[10] Scholarship on Kilpatrick reflects the tension between the essentialist and humanistic perspectives described in this chapter. Tenenbaum's (1951) affinity with his subject is clear in a sympathetic biography: "Only as we understand the damage done to children's personalities, the twisted and warped lives that resulted from traditional school practices, only then can we appreciate how illuminating, how healing, how truly revolutionary were Kilpatrick's contributions; how much he did to enrich children's lives; how he broadened the very foundation of education, making it was wide and pervasive as life itself" (107). Beyer (1997) wrote: "Kilpatrick's ideas … continue to offer educational alternatives to the emphases on efficiency, standardization, control and manipulation. He offered a way to make learning and living really unified, and to change the nature of public school classrooms" (479). Knoll (2012) is critical, seeing Kilpatrick as silent on students' "indifference, indolence, and want of discipline … with Kilpatrick the freedom for the student became a magic formula, and the learning by projects a panacea" (36).

involve teacher-directed activity. Kilpatrick ultimately abandoned his quest to shift the accepted meaning of "project" (Knoll, 2012). The episode reflected the tension between school-assigned and student-generated objectives that emerged in McHenry's superintendency and, a century later, in the STEAM Lab that is the empirical focus of this study. I will further discuss this tension later in this chapter.

Today, the professional staff at Eagle Lake connects their philosophy not only with McHenry's scientific essentialism—the superintendent underscored the importance of testing by pointing out that "we were built upon data" (Interview, 2016)—but also his humanistic principles. Mr. Jacobson, the STEAM Lab teacher whose program of freedom and choice is described in Chapter 3, stated that "If McHenry were alive today, I really believe that this is what he would be doing", and multiple administrators cited Eagle Lake's history in support of their modern-day humanistic views (Interviews, 2016-17), in particular the emphasis on student freedom (which they often called "voice and choice") in various programs at Eagle Lake.

In what follows, I first examine the origins of the association between freedom and personal development drawn by early humanistic educators, who—influenced in part by Eastern spiritual traditions—connected freedom and learning to the growth of the "soul." I then turn to the concept of *interest* as the core of the humanistic program, conceptualizing interest not as a disposition but a practice, visible as people willingly engage the "materials and methods of a developing activity" (Dewey, 1913). I present a theoretical model of interest based on the concept of "expression of the self" developed by Dewey (1913) and De Garmo (1911), which similarly points to the development of the "spirit" or "soul." (I will draw on this interest model in chapters 3 and 4, as a lens through which to understand the student learning experience in the STEAM Lab.) This section is followed by a discussion of early theorizations of tensions among the essentialist, scientific, and humanistic perspectives, tensions that surface in the empirical chapters that follow.

Freedom and development of the "soul"

During the early 1920's, Eagle Lake's school board funded a trip by McHenry to Europe, where he investigated the emergence of "new schools" that mirrored the "progressive" schools in the United States, ultimately publishing a book about his experiences (McHenry & Samson, 1926; Talcott, 1962). McHenry developed relationships with major European progressive figures, including the British educator Beatrice Ensor, who visited Eagle Lake. A noteworthy strand connects early European and American progressivism: an esoteric, universalist spiritual movement known as Theosophy. Theosophy, founded in New York in 1875 and still active to this day, is a syncretic movement that draws from diverse traditions including Jewish mysticism, Hinduism and Buddhism (Chajez & Huss, 2016). As I will show in what follows, many early progressive educators were Theosophists who believed that providing freedom of action to learners would lead to their personal development and to what Theosophy understood as "soul growth." Although more than a century old, I suggest that the association of learning with the growth of the "soul" anticipates modern-day research interest in questions of "identity" development (e.g., Holland et al., 2001; Pinkard et al., 2017): early theorists would have recognized an echo of their ideas in Holland et al's (2001) definition of identity as "the imaginings of self in worlds of action … [which are] important bases from which people create new activities, new worlds, and new ways of being" (5). Both "soul growth" and "identity development" point to the actualization of capacities within the individual that can lead to consequential changes in a life trajectory. In Chapter 4, I will interpret Kira's discovery in the STEAM Lab of a possible new future for herself as a designer and entrepreneur as a realization of a new *identity*, a transformational change in her "spirit" or "soul" that would have been recognizable to these early scholars. Here, I will describe in more detail the historical perspective of "soul growth" that informs the discussion of the empirical data in this study, especially the case of Kira's transformation. This view, I suggest, is at the center of the humanistic perspective.

During the early decades of the 20th century, as today, reform-minded educational scholars, educators, and policymakers developed their ideas through professional organizations, conferences, and journals. In the United States, the most well-known of these was the Progressive Education Association (see Graham, 1967), organized by Stanwood Cobb in 1919. In England, the two principal conferences discussing "new" or "child-centered" education were New Education Fellowship (NEF; Brehony, 2004: 735) and New Ideals in Education (NIE; Howlett, 2017; Newman, 2018), each of which published scholarly journals. Americans, including McHenry, were involved in the NEF, and—attesting to its significance—the 1916 NIE conference was attended by the United States Ambassador to Great Britain (Newman, 2018). Eastern philosophies strongly influenced key participants in these professional communities.[11] Cobb, the founder of the PEA, recalled in a memoir:

> At the age of fourteen I accidentally stumbled across Hindu mysticism into which I delved with great zest; and at fifteen naturally gravitated toward Theosophy and Unitarianism. These schools of spiritual thought, with the subsequent addition of Buddhism and New Thought, remained my spiritual food through college days. (1938: 10-11)

Ensor, a leading British Theosophist who would visit Eagle Lake, played the central role in organizing both NEF and NIE (Howlett, 2016: 38; Howlett, 2017; Brehony, 2004), and

[11] McHenry was a Christian, but maintained a universalist perspective that echoed Theosophical values and was reflected in the principles he drafted for Eagle Lake (Talcott, 1962). Moreover, McHenry visited India on a district-funded trip in 1931, where he had an audience with Gandhi (Talcott, 1962). In an interesting coincidence, Gandhi's grandson visited Eagle Lake in 2017, where he led an assembly for students.

established a Theosophical Fraternity which numbered hundreds of teachers (Brehony, 2004). Edmond Holmes, a high-ranking education official in the British government who along with Ensor was instrumental in organizing NIE, had published a major study of Buddhism (1908) and maintained a lifelong interest in Theosophy (Howlett, 2017).

These deep and extensive connections with Eastern philosophy generally and with Theosophy specifically shaped early humanistic educational thought. Among its core ideas, Theosophy understands the soul as evolving across lifetimes and seeking free and full expression in the life of each individual. In Holmes' widely-read book on education (1912), he wrote of "the evolution or growth of the soul … its ascent from 'weak beginnings' towards a state of spiritual perfection" (244-45). Critically, freedom in learning was seen as a necessary condition for this soul growth to occur. NIE conference participants were united as to "the fundamental right to liberty and freedom for the child in the classroom setting" (Howlett, 2017: 470). Maria Montessori, whose free-choice theories were the focus of the first meeting of NIE in 1914 and whose ideas influenced McHenry (McHenry & Samson, 1926), had joined the Theosophical Society in 1899 (Howlett, 2017). The co-founder of Theosophy, Helena Blavatsky, wrote:

> Children should above all be taught self-reliance, love for all men *[sic]*, altruism, mutual charity, and more than anything else, to think and reason for themselves. [Theosophist education] would reduce the purely mechanical work of the memory to an absolute minimum, and devote the time to the development and training of the inner senses, faculties and latent capabilities. We would endeavor to deal with each child as a unit, and to educate it so to produce the most harmonious and equal unfoldment of its powers, in order that its special aptitudes should find their full natural development. We should aim at creating *free* men and women. (Blavatsky, 1889: 270-271; italics in original)

Holmes, the British education official, visited Montessori's school in Rome, in which the principle of freedom of action for young people had been implemented, then returned to England and studied a free learning environment operated by Harriet Finlay-Johnson in Sompting, England (Howlett, 2017; Holmes, 1913, 1912). He argued that in these environments

> the training which the child receives may be said to be based on the doctrine of original goodness. It is taken for granted … that the child is … a "living soul"; that growth is of the very essence of his being; and that the normal child, if allowed to make natural growth under reasonably favorable conditions, will grow happily and well. (1912: 163)

This favorable view of the natural growth of the child warranted the argument by humanistic educators for the design of learning environments that provide freedom of action: if children are naturally inclined to develop in healthy ways, then freedom can be trusted to lead to productive development.

Interest and expression of the "self"

Other scholars of the period investigated the question of what would cause students to freely pursue certain lines of activity. Theorists had already proposed that the willing participation of students was important to the educational process. In one of the earliest treatises on education in the West, John Locke (1693)—perhaps the most famous Western political philosopher of all time—wrote of the importance of student "inclination" in learning:

> None of the things [students] are to learn, should ever be made a burthen to them, or impos'd on them as a *task.* Whatever is so propos'd, presently becomes irksome; the mind takes an aversion to it …
>
> They that love reading, writing, musick, &c. find yet in themselves certain seasons wherein those things have no relish to them; and if at that time they forces themselves to it, they only pother and weary to no purpose.
>
> Children … will learn three times as much when they are *in tune,* as they will with double the time and pains when they go awkwardly or are dragg'd unwillingly to it. (1693: 119-120; italics in original; "he" changed to "they")

The early "child-centered" theorists, building on the work of Rousseau (1762), Froebel (1826), Pestalozzi (1821), and Parker (1885) took a similar perspective. "We can have compulsory physical attendance at school," Suzzalo (1913) concludes, "but education comes only through willing attention to and participation in school activities … the teacher must select these activities with reference to the child's interests, powers, and capacities" (ix). Yeomans (1921) argued:

> You have to work with, and not against, the grain and gravitation of the individual. You determine what their enthusiasms are, and you make these yours. There is too often a breach, a gap—a broken circuit—between the teacher's enthusiasms and the pupil's. (1921: 7)

Modern-day academic psychologists have researched and theorized the questions of how and why people willingly engage and re-engage in challenging activity (e.g., Deci & Ryan, 1985; Maehr & Midgley, 1991; Anderman & Maehr, 1994; Csikszentmihalyi, 1990, 2000, 2014; Hidi & Renninger, 2006). One perspective distinguishes between "personal" and "situational" interest (Hidi, 1990), treating interest as either "a cognitive and affective quality that individuals carry with them from place to place" or "transitory, environmentally activated, and context-specific" (Schraw & Leman, 2001: 24). Hidi and Renninger (2006) proposed a four-phase model of interest in which interest evolves from situational to personal, noting that "the potential for interest is in the person but the content and the environment define the direction of interest and contribute to its development" (112). Outside of the educational psychology world, learning scientists have taken an ethnographic perspective (e.g., Pinkard et al., 2017; Barron, 2006; Azevedo, 2013), investigating empirically the "lines of practice" (Azevedo, 2011, 2013) that people follow as they assemble material, social, and ideational resources to develop an interest.

"Lines of practice" will be a unit of analysis discussed in chapters 3 and 4, as will another theoretical perspective from the early progressive period, and I return to that literature now. Despite its lack of an empirical foundation, a model proposed by De Garmo (1911) and Dewey (1913) provides a useful lens for studying interest in everyday practice. In De Garmo's *Interest and Education: The Doctrine of Interest and its Concrete Application* (1911) and Dewey's *Interest and Effort in Education* (1913)—which advanced his earlier monograph

Interest in Relation to the Training of the Will (1896)—activities become "interesting" when they develop, extend, and realize the "self." De Garmo and Dewey build on the psychology of William James and his theory of a "hierarchy of the me's" (1890: 292-305; 1892: 190-195), a precursor to Maslow's (1943) "hierarchy of needs." In this view, people are concerned first with securing the "material" conditions of their survival (their physical well-being, shelter, food, clothing, decorations, and possessions), then with "social" interactions and their place within society, and finally with the recognition and development of their "truest, strongest, deepest" selves (De Garmo, 1911: 17).[12] De Garmo (1911) concluded:

> Interest is a feeling that accompanies the idea of self-expression. It has its origin in the exhilaration, the sense of power, of mastery, that goes with every internally impelled effort to realize a condition for the survival of the self. (18)

Students will "take interest" in—willingly pursue—the "material and methods of a developing activity" (Dewey, 1913: 95) when the activity enables them to realize a material, social, or spiritual goal. De Garmo's language reflects the influence of the Eastern philosophy described above: he asserted that "the soul lives as well as the body, and it is about the soul's impulses that the interests of childhood cluster" (117) and called for "the awakening of the intellect, the enriching of the mind, the arousing of the desires, the direction of the outgoing efforts of the soul" (133).

Foundational tensions: "A maze of inconsistent compromise"

In the empirical chapters that follow, I will show that the implementation of the STEAM Lab at Eagle Lake produced, or revealed, a series of tensions or *dilemmas* (Cuban, 2001; Stevens 2000a). These dilemmas had a long history in the district in the interplay of essentialist,

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[12] In the psychoanalytic literature, this process has been described as the realization of the a priori, nascent potentialities of the self (Kohut, 1977).

scientific, and humanistic perspectives. Having presented above a series of concepts from early 20th-century educational literature that I will draw on in my presentation of the empirical data, I will close this historical strand by describing an early theorization of these tensions developed by John Dewey (1902).

Dewey identified a set of oppositional constructs, which he associated with two different "modes of doctrine" in education, one centered on the "child" and the other on the "curriculum":

> [The] fundamental opposition of child and curriculum … can be duplicated in a series of other terms. 'Discipline' is the watchword of those who magnify the course of study; 'interest' that of those who blazon 'the Child' upon their banner. The standpoint of the former is logical; that of the latter psychological. … 'Guidance and control' are the catchwords of one school; 'freedom and initiative' of the other. Law is asserted here; spontaneity proclaimed there. The old, the conservation of what has been achieved in the pain and toil of the ages, is dear to the one; the new, change, progress, wins the affection of the other. (1902: 9-10)

Dewey interpreted these pairs of constructs (characterized in this chapter as "humanistic" and "essentialist") as relational and dialectic, a continuum rather than a binary divide: the process of education is "one of interaction and adjustment" as "common-sense vibrates back and forward in a maze of inconsistent compromise" (1902: 10). The child and the curriculum, Dewey argued, are in fact "two limits which define a single process" (1902: 11) of ongoing reconstruction, as experience interacts with organized knowledge. Despite Dewey's insistence on the dialectical relationship between these two collections of ideas, however, the humanistic and essentialist principles he described formed the battle lines of an intense debate during the 1920s and 1930s (Cremin, 1961; Graham, 1967).

Arguing against what he perceived as a fashionable and fast-spreading humanistic view, Bagley (1939: 326) called for "an educational theory which places relatively heavy emphasis upon the induction of each generation into its social heritage as the primary function of education as a social institution." He contrasted this *essentialist* approach with a humanistic perspective that, he complained, "has become increasingly dominant in the United States during the past generation and which, in its well-intended efforts to improve American education, has, in effect, discredited and belittled the significance of a mastery of what we commonly call subject-matter, or in a large generic sense, knowledge" (1939: 326). Bagley and his supporters saw a central role for the school and teacher, and more broadly for compulsory instruction in the historic academic disciplines, in the organization of learning. Moreover, these "essentialists" understood the transmission of knowledge—in particular, the symbolic formalisms of the academic disciplines—as occurring most effectively through an activity structure of coercive instruction. Like Dewey, Bagley saw a set of oppositional constructs being deployed in the discourse of the time:

> Such words as "freedom," "liberty," and "democracy" make a strong popular appeal, and are readily and often unfairly coupled with such alleged opposites as "discipline," "control," and "authority." Of a somewhat more technical nature, but similarly charged with emotion to the initiated, are such ringing adjectives as "functional," "dynamic," "experimental," "instrumental," and "progressive," and such noble nouns as "activity" and "integration." Not very much skill in dialectic is needed to make these words carry conviction when brought into contrast with such unsavory adjectives as "structural," "static," "traditional," "formal," and "reactionary," or with such unpalatable nouns as "passivity" and "atomism." (1939: 327)

I have extracted these terms into a table of oppositions (*see* Table 1). These contrasts, in particular those between "freedom and initiative" and "interest" on the one side and "guidance and control" and "discipline" (in the sense of disciplinary subject matter) on the other recur consistently throughout the debates that raged into the 1950s (Cremin, 1961).

Humanistic	**Essentialist**
Interest	Discipline
Psychological	Logical
Freedom & initiative	Guidance and control
Spontaneity	Law
The new	The old
Change and progress	Conservation

Freedom	Discipline
Liberty	Control
Democracy	Authority
Functional	Structural
Dynamic	Static
Experimental	Traditional
Instrumental	Formal
Activity	Passivity
Integration	Atomism

Table 1. Humanistic and essentialist oppositions.

Dewey sought to achieve a balance between the two sides, arguing against an "anything goes" approach to education. As described in the previous section, Dewey (1913) had worked out a theory of interest, and proposed that an appropriately designed educational environment would facilitate this process:

> If we can discover a child's urgent needs and powers, and if we can supply an environment of materials, appliances, and resources—physical, social, and intellectual—to direct their adequate operation, we shall not have to think about interest. It will take care of itself.
> (Dewey, 1913: 95-96)

By the 1920's, however, Dewey would appear to reverse himself:

> There is a tendency in so-called advanced schools of educational thought ... to say, in effect, let us surround pupils with certain materials, tools, appliances, etc., and then let pupils respond to these things according to their own desires. Above all let us not suggest any end or plan to the students; let us not suggest to them what they shall do, for that is an unwarranted trespass upon their sacred intellectual individuality since the essence of such individuality is to set up ends and aims.
>
> Now such a method is really stupid. For it attempts the impossible, which is always stupid; and it misconceives the conditions of independent thinking. … Since the teacher has presumably a greater background of experience, there is [a] presumption of the right of the teacher to suggest to apprentices something of what they are to do. (1926: 3)

This passage was cited approvingly by Bagley (1939: 338). Although Dewey likely would have characterized this account as a clarification rather than a shift, an evolution of his views by the late 1920s was recognized at the time (Cremin, 1961; Graham, 1967). Dewey was a famously dense, reserved, and dry stylist (Ravitch, 1983; Cremin, 1961: 237-238), but his sarcasm in this passage and sharp characterization of his opponents' ideas as "really stupid" reflects a deep tension among educational theorists, with attacks of the time particularly aimed at Kilpatrick. Bode (1927) criticized Kilpatrick's project method as "a hit-and-miss affair—it dips in here and there, it gives no satisfactory perspective" (151) and argued that it was in danger of "evading instead of facing the problem of educational guidance or direction" (164). Lagemann (2000) suggests that because Kilpatrick's project method was vague in its description, "extreme … pedagogical experiments were often justified with reference to it" (239).

Kilpatrick's project method indeed entailed a remarkable prescription: the discouragement, to the point of rejection, of systematic instruction in disciplinary knowledge. Although in many ways Kilpatrick and Dewey were closely allied—Kilpatrick repeatedly emphasized his intellectual debt to Dewey, and Dewey, near the end of his life, wrote an appreciative introduction to Tenenbaum's (1951) biography—there was a critical difference between the two (Sutinen, 2013). Dewey reserved a central position for systematic instruction in disciplinary school subjects, which was "not provided for in Kilpatrick's situation-centered scheme of education" (Knoll, 2012: 20-21). Dewey's concerns over the balance of teacher-organized and student-led practices were brought forward in his keynote address as he accepted the honorary presidency of the Progressive Education Association in 1928. In that address, Dewey (1928) adopted a more essentialist stance against what he perceived as the excesses of certain schools (Graham, 1967), arguing that the teacher "has not only the right but the duty to suggest lines of activity" in light of their "riper and fuller experience" (203).

The distinction between the essentialist and humanistic views of the importance of subject matter represented one dilemma. By the 1920's a second tension had emerged among advocates for the "new" education. The foundational document of the Progressive Education Association (1919) identified seven "principles" (*see* Table 2; formatting added).

Principles of Progressive Education

I. Freedom to Develop Naturally

The conduct of the pupil should be governed by himself according to the social needs of his community, rather than by arbitrary laws. [*sic*]

Full opportunity for **initiative and self-expression** should be provided, together with **an environment rich in interesting material that is available for the free use of every pupil.**

II. Interest, the Motive of all Work

Interest should be satisfied and developed through:

(1) Direct and indirect **contact with the world and its activities**, and **use of the experience** thus gained.
(2) **Application** of knowledge gained, and correlation between different subjects.
(3) The **consciousness of achievement**.

III. The Teacher a Guide, not a Task-Master

It is essential that teachers should believe in the aims and general principles of Progressive Education and that they should have latitude for the development of **initiative and originality**.

Progressive teachers will encourage the **use of all the senses**, training the pupils in both observation and judgment; and instead of hearing recitations only, will spend most of the time teaching **how to use various sources of information**, including **life activities as well as books**; **how to reason** about the information thus acquired; and **how to express** forcefully and logically the conclusions reached.

Ideal teaching conditions demand that classes be small, especially in the elementary school years.

IV. Scientific Study of Pupil Development

School records should not be confined to the **marks given by the teachers to show the advancement of the pupils in their study of subjects**, but should also include both **objective and subjective reports** on those **physical, mental, moral and social characteristics** which affect both school and adult life, and which can be influenced by the school and at home. Such **records should be used as a guide for the treatment of each pupil**, and should also serve to focus the attention of the teacher on **the all-important work of development** rather than on simply teaching subject matter.

V. Greater Attention to all that Affects the Child's Physical Development

One of the first considerations of Progressive Education is the **health** of the pupils. Much **more room** in which to move about, **better light and air**, **clean and well ventilated buildings,** easier **access to the out-of-doors** and greater use of it, are all necessary. There should be frequent use of **adequate playgrounds**. The teachers should observe closely the physical condition of each pupil and, in co-operation with the home, make **abounding health the first objective of childhood**.

VI. Co-Operation Between School & Home to Meet the Needs of Child-Life

The school should provide, with **the home,** as much as is possible of all that the **natural interests and activities of the child** demand, especially during the elementary school years. These conditions can come about only through **intelligent cooperation between parents and teachers**.

VII. The Progressive School a Leader in Educational Movements

The Progressive School should be a leader in educational movements. It should be **a laboratory where new ideas, if worthy, meet encouragement; where tradition alone does not rule, but the best of the past is leavened with the discoveries of today, and the result is freely added to the sum of educational knowledge.**

Table 2. The Seven Principles of Progressive Education

After listing "freedom to develop naturally" and "interest, the motive of all work" as the first two principles, the PEA called for the "scientific study" of child development, to include not only marks within a graded curriculum but "objective" reports of "mental … characteristics." This provision, however, was connected to an assertion that such reports should serve as "a guide for the treatment of each pupil" and highlighted "the all-important work of development rather than on simply teaching subject matter." The uses of these objective reports—whether as a "guide for treatment" of the individual student or as a system of ranking and measurement—would be a point of tension within the progressive movement. Following from Thorndike's (1913) proposal of "laws" of learning and building on ideas for intelligence testing (Kelly, 1914), one strand of reform practice took a technical approach that sought more efficient and precisely calculated methods of transmitting knowledge to students and then measuring their ability to respond to test questions, anticipating contemporary concerns with "data" in education. Reflecting this tension, Rugg & Shumaker (1928) identified a split between "project methodists" and "scientific methodists." Journals of the day were filled with a "pretentious scientism" (Ravitch, 1983: 46), describing experimental techniques and methods for more efficient instruction and devising more complex instruments for assessment.

Holmes (1912) worried that school's emphasis on quantitative outcomes conflicted with a focus on the development of the student:

> The truth is that inward and spiritual growth, even if it were thought desirable to produce it and measure it, could not possibly be measured. The real "results" of education are in the child's heart and mind and soul, beyond the reach of any measuring tape or weighing machine. (1912: 52)

Holmes' concern about the measurement of "inward" growth was shared at Eagle Lake. Unlike Holmes, McHenry saw value in measuring personal development, but struggled to find a method to assess the program of social and creative activities:

> It disturbed [McHenry] to have to rely on subjective judgment to evaluate the results of this part of the curriculum. His own background in science and the effort he and his staff put forth to construct a 'scientific curriculum' in the teaching of the common essentials made him quite conscious of the lack of objective means to measure the success of that part of the curriculum which was devoted to group and creative activities. He made several attempts to devise measurement techniques, but made little progress. (Talcott, 1962)

These two dilemmas—tensions between the difficult-to-quantify "outcomes" of humanistic education and the need for scientific measurement, and between the disciplinary focus of essentialism and competing claims for learner freedom and interest—were very much present in modern-day Eagle Lake, evident in administrators' comments in the empirical data that follows and in particular in the case of Kira, whose experience in the STEAM Lab is the subject of Chapter 4.

"Structured-choice" learning environments

Dewey (1913) called for "an environment of materials, appliances, and resources—physical, social, and intellectual—to direct their adequate operation" (95-96). The PEA's first principle prescribed "an environment rich in interesting material that is available for the free use of every pupil" (1919). The STEAM Lab at Eagle Lake reflected these design principles, constituting a *structured-choice learning environment* (Stevens, personal communication, 2017). In this dissertation, I define a structured-choice learning environment as one in which students are provided with a diverse set of challenging activities and creative tools, along with informational resources (such as texts or videos) that may be readily consulted; *and* may choose which activities to work on and for how long.

Each of these dimensions—freedom of choice *together with* ready access to diverse materials and resources to assist in their use—is necessary to constitute a structured-choice learning environment. This definition is distinct from modern conceptualizations of "project-based learning" (e.g., Krajcik & Blumenfeld, 2005; Stevens, 2000a), which typically emphasize physical interaction with materials in a context of relatively scripted participation in a teacher-defined activity. The definition further excludes open-ended "passion project" or "genius hour" activities that do not constrain student choice (e.g., Krebs & Zvi, 2015). It also excludes "electives," in which a student selects a class such as coding or music, but the organization of moment-to-moment activity once class starts does not allow choice. It should be noted that student "freedom" in a choice-based school learning environment does not include the right to leave the classroom.

Eagle Lake provided a structured-choice learning environment in the STEAM Lab. The room was stocked technology, design, and art activities and tools; Mr. Jacobson, the teacher, authorized "choice" for students. The empirical data in Chapter 3 will show that students typically entered the class, quickly organized their materials, and worked consistently and often enthusiastically in a clear example of the "wholehearted purposeful activity" of Kilpatrick's project method. In this dissertation, then, I consider Eagle Lake's structured-choice learning environment in the STEAM Lab as a modern-day *experiment with the project method*.[13]

Research Context & Research Methods

Learning is integrally bound up with its cultural, organizational and institutional context (Cole, 1996; Cole & Packer, 2016; Lemke et al., 2015; Ogawa et al., 2008). The moment-to-moment learning experience of a student in a classroom is shaped directly by concrete organizational requirements and technologies (such as grading rubrics and classroom management software) and guided more subtly and indirectly by cultural beliefs (such as a common understanding that student work should be letter-graded). Accordingly, Ogawa et al. (2008) argue for a multi-level approach to educational research:

> As researchers who are interested in learning activity, we must frame the immediate social relations that produce learning within the organizational structures and broader institutions that shape those relations. Practically, this calls for developing methods for data collection and data analysis that connect multiple layers of context. (93)

"Eagle Lake Middle School" represented an ideal research context for this integrating perspective. District leaders had established the "Tech21" class in a newly-remodeled STEAM

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[13] The title of this dissertation—*An Experiment with the Project Method*—deliberately, though provocatively, recalls Ellsworth Collings' (1923) dissertation *An Experiment with a Project Curriculum*, advised by Kilpatrick and later published by Macmillan. Collings claimed to investigate the project method in a rural Missouri school, but Knoll (1996) shows that Collings' vivid narrative misrepresented important facts, and that Collings falsified key dates in his data so as to make it appear that the school had used Kilpatrick's method when it had not. My intention in this study is to honor Kilpatrick's sense of "project" and to investigate it with integrity, using modern qualitative research methods.

Lab, providing the "environment of materials, appliances, and resources—physical, social, and intellectual—to direct their adequate operation" (Dewey, 1913: 95-96) and choice-based activity structure that are central to a structured-choice learning environment. The district's director of technology had acquired the choice-based program FUSE Studio (Stevens et al., 2016), seeking to add FUSE to its already-diverse collection of STEAM activities in Tech21, and the Tech21 teacher participated in FUSE's training and professional development program. These factors—the material environment and the teacher training—supported my identification of the STEAM Lab at Eagle Lake as a structured-choice environment. Second, Eagle Lake promised to be a highly facilitative research context: administrators were eager to participate in this study, made themselves available for interviews, and allowed me to observe the Tech21 class at length. This allowed me to collect and compare data at the district level and at the classroom level. Third, as described above, Eagle Lake had a long and extensively researched history of educational innovations dating back nearly a century, thus making an extensive data set available for historical context and perspective. Ogawa et al. (2008) propose that studies of learning activity be grounded in such a history:

> [O]ur understanding of the links between learning and social context would be advanced by studies that connect the historical development of educational organizations to the institutional environments that provided the social and cultural resources, or building blocks, that were used in their development. (92)

Taken together, these characteristics of Eagle Lake—the fidelity of the structured-choice implementation, the availability of research participants from the superintendent down to the students, and the abundance of historical materials—made it an ideal context to conduct a multi-level investigation.

These resources also suggested a study design that would examine the institutional, organizational, and classroom contexts together. I first researched Eagle Lake's history, reading

McHenry's memoir (McHenry & Marbury, 1963) and studying two dissertations (Talcott, 1962; Schumann, 1970) that each included reproductions of primary-source materials, such as the goal card, from Eagle Lake. I immersed myself in the literature of the period, including Kilpatrick's work (1925) in which he presents his view of Eagle Lake. I then researched contemporary district documents, focusing on representations and justifications made to the Board of Education about the STEAM Lab. I conducted a series of interviews with school and district leaders to better understand their perspectives on the STEAM Lab and Eagle Lake's "progressive" history. I then conducted ethnography in the STEAM Lab itself, interviewing the teacher extensively. I concluded the data collection by conducting additional interviews with administrators to obtain their perspectives on phenomena I had observed. This approach thus provided rich data at the levels of the district, school, teacher, and student.

Discussions of the research methods for the various components of this dissertation are included in Chapters 2, 3, and 4. In brief, I initiated the research with a series of hour-long interviews with the school and district leadership teams in November 2016. I then began observations in the STEAM Lab. 86 students and their parents provided written consent to participate. I attended 3 Tech21 classes per day on 35 randomly sampled observation days between November 2016 and June 2017, and conducted follow-up interviews with 3 students in November 2017. The extended nature of the fieldwork in the STEAM Lab allowed me to establish a close relationship with the teacher, to develop good informal conversational connections with the students, and to see a diverse range of student experiences. I conducted a 2nd round of interviews with administrators in the fall of 2017, this time exploring issues related to ethnographic cases I had constructed. This enabled me to produce a multi-level view of these phenomena, in particular the difficult case of Kira that I present in Chapter 4. On two occasions, I also observed other classes in the district, including a 4th-grade math class and an 8th-grade science class attended by several students who I had observed in Tech21. I sampled these in order to observe "traditional" classes at Eagle Lake, that is, classes designed in accordance with the scientific essentialist logic described in Chapter 2. I reviewed archival materials, such as the "goal card" of the 1920's displayed above and letters to the editor of the local newspaper for and against McHenry's reforms, providing the historical perspective that the multi-level view proposes. Finally, I reviewed present-day district memoranda and policy documents. These materials were formal, public statements about administrators' goals that complemented the more informal, conversational statements they would make to a researcher during an interview. Notably, the memoranda from administrators to the Board were designed to motivate a vote to authorize budget expenditures for the STEAM Lab. The assertions were deliberately anodyne, intended to build consensus. As such, the "pro forma" or boilerplate statements in these memoranda provide a window into widely accepted beliefs in the community—ideas that administrators expected Board members to take for granted. In this way they provide evidence of the institutional logics which I explore in Chapter 2.

The account of student learning presented in Chapter 3 adopts the methodological approach and epistemological commitment of *constructivist grounded theory* (Charmaz, 2000, 2006). In grounded theory, the qualitative researcher seeks to build (or "discover") theory through a systematic, inductive, recursive process of data collection and analysis (Glaser & Strauss, 1967; Corbin & Strauss, 2008). Since the first iteration of the theory, distinct paradigms within qualitative inquiry have emerged, ranging from positivist views that assume the existence of objective, discoverable truth to constructivist views that assert the relativism of local, specific, constructed realities (Guba & Lincoln, 1994: 108; Mills, Bonner, & Francis, 2006). Early grounded theory reflected the positivist science of the period, but "evolved" grounded theory (Strauss & Corbin, 1994) began to acknowledge that researchers' perspectives always shape the process of theory development:

> A theory is not the formulation of some discovered aspect of a preexisting reality "out there." To think otherwise is to take a positivistic position that … we reject, as do most other qualitative researchers. Our position is that truth is enacted: Theories are interpretations made from given perspectives as adopted or researched by researchers. (279)

The constructivist stance "assumes the relativism of multiple social realities, recognizes the mutual creation of knowledge by the viewer and the viewed, and aims toward interpretive understanding of subjects' meanings" (Charmaz, 2000: 250). As applied to grounded theory, this position sees the development of theory as a dialectical process in which researchers build concepts and understandings interactively with the phenomenon being studied, and acknowledges that researchers "create and maintain meaningful worlds … conferring meaning on their realities" (Charmaz, 2000: 269). Constructivist grounded theory denies the existence of an independent social truth accessible to any observer. Accordingly, this study does not claim that the phenomena and processes documented here represent universally discoverable truths. In particular, it rejects Glaser's (1978) view of the researcher as a tabula rasa and his counsel to avoid reading literature relevant to the phenomenon of interest before conducting fieldwork. The literature reviewed above—as well as my own personal convictions about school formed as a student, parent, and teacher—actively informed the research questions, data collection, and ongoing analysis.

Organization of the Dissertation

This chapter has provided an introduction to the dissertation as a whole. I first surveyed the history of the Eagle Lake school district, widely recognized in the 1920's and 1930s for its "progressive" practices. As an overall conceptual framing, I sketched 3 composite historical perspectives on the purposes of education, which I called essentialist, scientific, and humanistic. I suggested that a program of "scientific essentialism" has come to characterize American schools, and surveyed literature from what I called an "outsider" critique of this model. I described an alternative: humanistic education, designed on the principles of freedom, interest, and the personal development of the learner. I introduced the research context and presented an epistemological and methodological stance of constructivist grounded theory that guided the research. I advance three arguments in the following chapters.

In Chapter 2, I draw on a frame from institutional theory and characterize the three historical perspectives as *logics.* I show that these logics were present in the discourse and the practices of students, teachers, and school and district leaders at Eagle Lake. Through analysis of interviews with administrators and a study of memoranda provided to the School Board, I propose that modern-day administrators were engaged in an ongoing and highly contested effort to find a new compromise among these logics. I analyze a meeting in which the logics were actively contested by a teacher, a department chair, and an administrator, using this meeting as a context in which to show how institutional change can be analyzed at the level of moment-to-moment interaction.

In Chapter 3, I first describe sociocultural perspectives from the learning sciences that form the basis for the ethnographic fieldwork at Eagle Lake and the definitions I use for student learning. I show that students learned powerful software, assembled complicated devices, and created complex and sometimes original works of technology, art, and design. From moment-to-moment observation of student activity, I propose a descriptive process model I call *constructive interaction*, a general account of how students learned the design and technical skills they needed to achieve their goals. For many students, Eagle Lake achieved goals consistent with the humanistic logic, discovering new interests and experiencing personal and social growth. I then present a series of ethnographic cases of student learning.

In Chapter 4, I examine how the logics came into conflict in the experience of a single learner, a 7th-grader I call Kira. Troubled in school, Kira found a home in the STEAM Lab. She learned difficult software in order to design and fabricate a valued object, then became a skilled instructor for her colleagues. Interviews with Kira revealed that the experience had been meaningful and powerful to her, leading to a transformation in her identity. Kira's teacher, Mr. Jacobson, recognized and valued her achievement, but struggled with Eagle Lake's available models for assessment and grading. I suggest that in this case, Eagle Lake's attempt to find a workable compromise among the logics failed, and that Kira experienced harm as a result.

In the closing chapter, I introduce Cuban's (2001) concept of managing instructional dilemmas and seeking "better compromises." Kira's case revealed a tension in which the beliefs and values embodied by the diverse logics came into conflict. Following Cuban's framework and drawing on conversations with school and district leaders about Kira's story, I propose a new compromise with a simple recommendation. This work may provide guidance for schools and districts developing learning environments that provide increased freedom and choice for young people in school.

CHAPTER 2

Logics of Instruction: Negotiations & Compromises

Abstract

In this chapter, I examine the organizational and institutional environment in which a structured-choice learning environment, the Tech21 class in the STEAM Lab at Eagle Lake Middle School, emerged and appeared to stabilize. How did this approach to classroom instruction—distinct from Eagle Lake's scientific essentialist program—come to be recognized as legitimate and to be solidified and sustained? I first establish a conceptual framework using the institutional logic (Thornton, Ocasio, & Lounsbury, 2012; Friedland & Alford, 1991) perspective. I characterize the historical perspectives of K-12 instruction sketched in Chapter 1 as *logics of instruction.* In the empirical section of the chapter, I use interview and ethnographic data to explore the ways in which these logics were present and contested at Eagle Lake. I describe the relative prominence of the various logics within accounts given by the professional staff about Eagle Lake's modern-day practices. I then describe a meeting in which the Tech21 teacher, the science department chair, and the district's technology director debated a proposed change to the STEAM Lab, showing how the logics were spoken for and contested in moment-to-moment interaction. I argue that the structured-choice learning environment became stabilized in a process of what Strauss (1978) calls a "negotiated order," as Eagle Lake established a compromise among the logics of classroom instruction.

Introduction

In Chapter 1, I discussed Eagle Lake's history and modern reputation as a district that actively experimented with reform instructional practices, and discussed the foundational tensions that have long been associated with the district. A century later, these tensions came together in Mr. Jacobson's Tech21 class in the STEAM Lab. With a choice-based activity structure and free availability of diverse, complex technical and design challenges for students, this class contrasted with the scientific essentialist program that characterized most curricular activity elsewhere in the school. What moves did organizational actors make to try to give this humanistic learning environment legitimacy and to stabilize it within Eagle Lake's educational routine? I first sketch a conceptual framework from institutional theory and frame the historical perspectives described in Chapter 1 as *logics of instruction*. I show these logics in action in Eagle Lake's history and its present-day practices. Drawing on ethnography and interview data, I will argue that participants established a "negotiated order" (Strauss, 1978) among these different conceptions of instruction—balancing essentialist, humanistic, and scientific logics—that enabled the environment to stabilize.

Theory & Literature

Concepts from institutional theory

Institutions. Institutions are "social structures that have attained a high degree of resilience" (Scott, 2001: 48). The study of institutions has been a concern across the disciplines of the social sciences—including anthropology, political science, sociology, psychology, and economics—for more than a century (e.g., Schutz, 1932/1967; Mead, 1934; Durkheim, 1912/1995). Institutions consist of formal and informal rules, mechanisms of monitoring and enforcement, and systems of meaning that provide stability and consistency in social practices (Scott, 2008; Campbell, 2004). Institutional ideas are “carried” through symbolic systems, relational systems, routines, and artifacts (Scott, 2008). Within institutional theory, scholars have increasingly focused on the cultural and cognitive dimensions of institutions: how certain practices come to be legitimized, taken for granted, sustained, and changed (Scott, 2013). This “neoinstitutional” perspective attends to the ways in which actions and decisions are subject to cultural processes that organize sense-making and provide participants with rules, norms, and belief systems that guide and structure appropriate conduct (Berger and Luckmann, 1967; Meyer and Rowan, 1977; DiMaggio and Powell, 1983; Weick, 1995).

Institutional logics. Scholars have developed the concept of *institutional logics* (Thorton, Ocasio & Lounsbury, 2012; Thornton & Ocasio, 2008; Friedland & Alford, 1991; Scott et al., 2000). Thornton & Ocasio (1999) describe logics as

> socially constructed, historical patterns of material practices, assumptions, values, beliefs, and rules by which individuals produce and reproduce their material subsistence, organize time and space, and provide meaning to their social reality. (804)

Logics “come together at particular periods of time and enable certain kinds of actions—and not others” (Rigby, 2014: 611). I define a logic as a *set of shared understandings about the significance and meaning of activity, definitions of what and who belongs, and expectations of how people and things will act on one other*. The logics perspective has informed empirical studies of institutional change. For example, Scott et al. (2000) studied the evolution of health care organizations and described an early logic of “professional dominance,” in which physicians were recognized as the experts and final arbiters of treatment decisions. This logic was replaced by a logic of “managed care,” in which health care was overseen by corporations and understood as a series of economic transactions governed by cost-benefit analyses. Logics involve language, which can characterize practice as deviant or normative. In the field of mergers and acquisitions, for example, the same practice might merit the label "corporate raider" or a "strategic investor". Logics also involve objects and technologies. Within the logic of managed care, both patients and physicians expect that an examination room will contain a computer running practice management software that includes, for example, diagnostic codes that an insurance company will use to process a claim. Placing certain technologies within a setting thus mobilizes that logic within the setting.

Interactional institutionalism. In recent years, scholars have turned their focus to the interactional phenomena through which processes of institutional change occur. Barley (2008) argued for empirical investigation of everyday contexts in which consequential talk and action is occurring. This practice-oriented view guided Hallett's (2010) call for an "inhabited institutionalism" (66) focused on local, situated processes of work activity, social interaction, and negotiation of meaning. This perspective invites an empirical approach of closely observed ethnography, drawing on interactionist traditions in sociology, in which these processes may become visible and the local, moment-to-moment components of institutionalization can be documented and analyzed (Barley, 2008; Spillane, 2012). Barley (2008) explicitly sought to bring institutional theory into conversation with the Chicago school of interactionist sociology developed by Hughes (1942) and his students (see Becker, 1999). I refer to this perspective sketched by Spillane (2012), Hallett (2010), and Barley (2008) as *interactional institutionalism*, and in this chapter I treat *organizational actors in interaction with their social and material environment* as an important unit of analysis in studying institutional change. Such "micro" level interaction, from this view, is the context through which "macro" level processes of institutionalization are contested, negotiated, and enacted.

Although the term *actor* has a strong connotation as *person* and appears to be used exclusively in that way within the institutional literature, in this chapter I use it in the sense proposed by the sociologist Bruno Latour. Latour (1987, 2005) argues for the symmetry and interdependence of objects and people in the analysis of everyday activity. Both an object and a person may function as an "actor" within a network of activity, and each may organize and influence the actions of the other. For example, a grade book, a learning management system, a teacher, and a principal are all actors within the network that produced a grade for Kira, the Eagle Lake student whose story is presented in Chapter 4. The researcher's job is to "trace the associations" in a such a network (Latour, 2005). In the case of Kira, Mr. Jacobson was required by the school software to enter a grade and stated that he felt obligated to produce "evidence of learning" for the principal, even though he was never asked to do so. Scott's image of symbolic systems, relational systems, routines, and artifacts as "carriers" of institutional ideas (2008) invites this connection with actor-network methods. Analysts can unpack the ways in which these carriers interact so as to produce, reproduce, or change institutional logics. Accordingly, in this study, I will seek to "inhabit" institutional logics with both social and material actors in this Latourian sense and to analyze ways in which these actors interact to reproduce different logics.

Institutional entrepreneurship. The institutional literature reflects a tension between a view of institutions as constraining change and a view that individuals can, even within these stabilizing structures, exercise agency and bring about change (Scott, 2013; Powell & Colyvas, 2008). Institutions produce patterns and regularity in social behavior but also provide a framework through which innovation can emerge and new practices can become stabilized and seen as legitimate (Giddens, 1984; Colyvas & Jonsson, 2011). Individuals, in this view, can use institutional frameworks to exercise agency and create change. DiMaggio (1988) argued that a focus on macro-level social and organizational experience is insufficient to account for the origins, reproduction, and disappearance of institutions and argues for attention to individual interest and agency in building a more complete and integrated picture of institutions. Accordingly, DiMaggio coined the term “institutional entrepreneur,” an actor who recognizes a chance to realize a valued goal and mobilizes resources to take on an institutionalization project. Such ventures require overcoming organizational inertia and disrupting an existing “package” or ingrained, self-reinforcing network of practices, artifacts, and routines (Becker, 1995). Institutional entrepreneurs organize networks of actors in order to achieve organizational goals.

Summary. Neoinstitutionalism, a strand of institutional theory, attends to the processes by which cultural practices come to be legitimized, accepted, and taken for granted. Organizational scholars have sought a more closely observed, ethnographically oriented approach that “inhabits” institutions with work activity and moment-to-moment communications (Barley, 2008; Hallett, 2010; Spillane, 2012). I broaden this perspective to include both social and material dimensions of activity and call the study of the relationships among these organizational actors *interactional institutionalism*. Institutional *logics* comprise both ideational resources and material practices; actor-network techniques (Latour, 2005) connect these two dimensions of logics. Institutions are sources of both persistence and change (Colyvas & Jonsson, 2011), and institutional entrepreneurs exercise agentive action (DiMaggio, 1988). This chapter draws on the interactional institutionalist approach and seeks to connect neoinstitutional theory with actor-network techniques (Latour, 2005) to analyze how institutional entrepreneurs mobilized various actors to create organizational change at Eagle Lake.

Logics of instruction

In Chapter 1, I described 3 composite historical perspectives on the purposes of education, adapted from taxonomies proposed by Kliebard (1986), Cremin (1961), Egan (1997), and Labaree (1997). *Essentialist* education prioritizes disciplinary knowledge, the organization of instruction by subject area, and the systematic transmission of the Western cultural and scientific heritage (National Education Association, 1893; Bagley, 1939; National Governors Association, 2010; NGSS Lead States, 2013). The *scientific* perspective emphasizes quantitative measurement to monitor student progress within a defined educational program (Kelly, 1914; Binet & Simon, 1916; Terman, 1916; Yeomans, 1921). *Humanistic* education is concerned with the freedom, interests, goals, concerns, and personal development of the learner (Dewey, 1902; Kilpatrick 1918, 1925; Stevens, 2020; Stevens, 2011). In a footnote, I described other historical perspectives: scholars and practitioners have also conceptualized school as a place to prepare young people for the responsibilities of democratic citizenship (e.g., Dewey, 1916; Rudduck & Flutter, 2004; Cook-Sather, 2006; Mitra, 2004; Fielding, 2001), create a more just and equitable society (e.g., Counts, 1932; Rugg, 1931, 1933, 1936; Freire, 1970; Bang & Vossoughi, 2016), train people for jobs (e.g., Della Vos, 1876; Snedden, 1921; Gordon, 2003), develop the national economy (e.g., National Commission on Excellence in Education, 1983; National Science & Technology Council, 2018), or get the edge on other people for scarce positions in college and the high-salaried professions in a market economy (e.g., Labaree, 1997; Markovitz, 2019; Packer, 2019).

To this point, my discussion of these perspectives has been at the level of principles and philosophies about learning. To analyze how these philosophies were translated into practice, I will conceptualize them as *instructional logics.* A full analysis of these diverse logics and how they move from philosophy into networks of practice is outside the scope of this dissertation. In repositioning the historical perspectives as "logics," I seek to call attention to their concrete and practice-oriented qualities. Logics include not only assumptions and beliefs but also social and material actors that relate to each other through empirically observable accountabilities (Strauss, 1985; Stevens & Hall, 1998). For example, while the essentialist *philosophy* upholds general principles of the importance of disciplinary knowledge, the essentialist *logic* includes particular standards documents, such as Common Core math (corestandards.org., n.d.), around which school professionals must organize instruction. Similarly, while the scientific philosophy calls for measurement of student progress, the scientific logic includes specific actors such as reflection essays, which students must produce, and a learning management system, into which teachers must enter letter grades.

Research context

Schools are productive contexts for examining processes of institutional change. They function as sites in which to explore the relationship between field-level phenomena, such as a statewide movement toward new reading instruction methods, and local practice, such as one school's implementation of a particular reading program (Coburn, 2004; Hallett, 2010). At the time of this study, conducted between 2016 and 2019, a national commission had spoken for "21st century skills" (National Research Council, 2012) and widely read books were advocating the development of "grit" (Duckworth, 2016) and "growth mindset" (Dweck, 2006), while an "opt-out" movement against standardized tests was gaining momentum (Packer, 2019). These debates in the field of K-12 education formed the institutional context for an examination of local practices in a middle school in the American suburb of "Eagle Lake."[14] Eagle Lake is

[14] As stated in Chapter 1, names and all identifying details, including certain citations (e.g., two dissertations about Eagle Lake), have been changed to preserve anonymity of the school. In cases where participants mentioned a

among the wealthiest communities in the United States. With a population of about 10,000, the median household income is over $200,000. Most students at the middle school where this study was conducted are white, with a small fraction of Asian and Hispanic students. Many students' parents commute into the city for jobs in finance, law, investment banking, real estate, and consulting. During the time of this study, as I will show, the humanistic, essentialist, and scientific logics were each present at Eagle Lake Middle School. Conferences that highlighted learning environments based on creativity and making, such as MIT's *Constructing Modern Knowledge* and the educational technology event SXSW EDU, were part of the professional learning environment for Eagle Lake educators and administrators; I spoke with one Eagle Lake administrator at SXSW EDU in 2017. The author Ted Dintersmith hosted a screening and discussion of his humanistic book *Most Likely to Succeed* (Wagner & Dintersmith, 2016) in a nearby community; many Eagle Lake parents attended. School and district leaders routinely mentioned student "voice and choice" and other reform-oriented constructs and catchphrases, such as "personalized learning," that circulated at conferences and on education blogs. At the same time, however, the school board at Eagle Lake placed strong pressure on district leaders to raise test scores and to prepare students for an academically challenging local high school or for Eastern boarding schools (Interviews, 2016-18). Such competing pressures were common at many American schools during this period, but Eagle Lake represents a particularly valuable research context because these logics and their associated tensions had deep historical roots in the community.

Methods

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locally identifying detail in a quotation, I have substituted a pseudonym (e.g., "Science Wizards") without placing the pseudonym in brackets in order to improve readability.

Between November 2016 and October 2018, I conducted field research at Eagle Lake in the participant observation tradition (Spradley, 2016; Delamont, 2004; Becker & Geer, 1957). Most of this time—approximately 120 hours—was spent in the Tech21 class in the school's new STEAM Lab. I observed students, talked with them, took fieldnotes, videorecorded, and on most days spoke informally for a few minutes with their teacher, Mr. Jacobson, about what we each had seen. This data is presented and analyzed in chapters 3 and 4 of this dissertation; in this chapter, I focus on my interviews with school and district leaders and on my observation of a meeting between two teachers and an administrator.

At the start of the research (November 2016) I conducted 10 semi-structured qualitative interviews (Weiss, 1995) with the professional staff at Eagle Lake, and spoke again with 3 administrators after most of the field observations were concluded, presenting them with anonymized case narratives. In addition, during my time in the STEAM Lab, I had occasion to observe and audiorecord Mr. Jacobson's interactions with other faculty members, with visiting delegations, and with a representative of an educational technology company that was trying to sell its software to Eagle Lake.

I transcribed the interviews and meetings and entered them into the qualitative coding software AtlasTI. I developed a simple, low-inference coding scheme based on the 7 logics, looking for statements that expressed the foundational ideas from the various perspectives or referred to a way in which they were operationalized. For example, if an interviewee mentioned a standards document or stated a belief that there were certain things students needed to know, I coded that as *essentialist*. Table 3 shows examples of how this method was applied to the data.

Logic	**Description**	**Examples**

essentialist	*Speaker refers to disciplinary knowledge, standards, subject-based organization of instruction, or need to direct students*	"We're definitely more reactive and needing to be more responsive to state standards and goals and things than what we had nearly 30 years ago." "I think right now what we do is we say, 'Here's math, learn math.' Then we go through that or here's science, and memorize it, and take a test, and then regurgitate it."
scientific	*Speaker refers to measurement, standardized tests, administrative efficiency, or research on learning processes*	"We're always desperate for data that affirms progressive practice as legitimate [in the same way as] the MAP test or the PARCC exam." "I love data. ... I like using it behind the scenes, not to drive instruction but to inform instruction. I think we have to be careful that we don't over-rely on one data point … but I love it."
vocational	*Speaker refers to the preparation of students for careers, to the needs of employers, or to the development of the local or national economy*	"It's important that they know to use these new [technology] tools. ... Already we're seeing that in the workplace. It doesn't matter where you work at. You could work at a theater company. You could work for a law firm. People that have that [technology] skillset have a distinct advantage in the environment over their colleagues." "Are they being encouraged to pursue careers in STEAM? Ultimately, that's what we want, is to bring more people into those fields so that we don't fall victim to other societies."
democratic	*Speaker refers to the responsibilities of citizenship or to participation in democratic processes*	"Obviously we have responsibilities to give instruction, but [student voice] is a huge piece of progressive education to me. Democracy extends student voice. Democracy, according to John Dewey and what I really truly believe too, is not about majority rules, and in these interesting political times, I think it's very important for us to recognize."
competitive	*Speaker refers to obtaining credentials for success in a market economy, to individual status attainment, or to education as being a private good*	"I think we now live in a time where parents, adults have a lot of access to information [about student performance]. There's also a great deal of information to succeed, to kind of position your child to be successful."

		"I have some parents who just want the numbers. … They get nervous. 'What does that mean for my child?' 'How do I keep up?' 'How do I compete?'"
social reconstructionist	*Speaker refers to remaking society toward the goals of justice and equality*	"I taught at a Catholic school and I went to [a Jesuit] University where a lot of it was giving back and social justice. I think one of the ways that I could give back here is to help these future leaders … with their successful parents, and connections, and things that I feel that they're going to have, if they can remember giving back and trying to solve problems, and not just doing it for profit, but to make the world better."
humanistic	*Speaker refers to the freedom, interests, needs, goals, creative expression, and personal (non-academic) growth of the student; speaker refers to the "four C's", "21st century skills", or "soft skills"*	"I went to [observe] an inquiry project and I asked the kids, 'What do you like about this?' [They said] 'Well this is where I get to really be in charge, of my day. This is where I get to determine what I'm learning, and I love it, I look forward to it all day long.'" "We're developing a fully formed human being, so it's this whole idea of whether it's educating the whole child, or it's the different domains of human existence. You're developing not only content knowledge, but obviously problem-solving knowledge, skills, mindset, empathy. All of those things are part of what I would consider a progressive education."

Table 3. Coding scheme to identify instructional logics.

I sought to connect these logics to the central research question of how the choice-based environment in the STEAM Lab came to be seen as legitimate and to be sustained. In particular, I was sensitive to Hallett's (2010) recommendation to attend to how processes of institutionalization might occur through "people, their work activities, social interactions, and meaning-making processes" (53). Accordingly, I attended closely to moments in interaction in which teachers and administrators invoked logics to explain and legitimize certain practices, or identified routines and artifacts that were part of these practices. One meeting, a complex interaction between the science department chair, the STEAM Lab teacher, and an administrator, was selected for particular analysis. In this effort, I was influenced by conversation analysis (Goodwin & Heritage, 1990; Pomerantz & Fehr, 1997; Schegloff, 1992; Sacks, Schegloff & Jefferson, 1978) and discourse analysis (Gee, 2004). Conversation analysis

> seeks to describe the underlying social organization—conceived as an institutionalized substratum of interactional rules, procedures, and conventions—through which orderly and intelligible social interaction is made possible. Analysis of this substratum requires an integrated analysis of action, mutual knowledge, and social context. (Pomerantz & Fehr, 1997: 283)

From this perspective, institutionalization may be understood in the terms Mehan (1982) used to describe "culture": "as intersubjective praxis (human productive and interpretive practices) instead of either a subjective state or an objective thing" (53). I describe my use of conversation analysis here as an influence, rather than a method, because I am less interested in the fine-grained, multimodal mechanics by which the participants executed their meeting (Sacks, Schegloff & Jefferson, 1978) and more interested in the moves by which meaning and outcomes were negotiated during the conversation. I focus in particular on language, including the "packaging" of reference terms (Pomerantz & Fehr, 1997). Erickson (2004) writes that the "vocabulary of a language can be thought of as a kind of social institution, a tool [used] in the practice of daily life" (14). Because the meeting was audiorecorded rather than videorecorded, I was for the most part only able to make use of the methods of interaction analysis (Hall & Stevens, 2016; Jordan & Henderson, 1995) through the modality of talk, although in the field notes I took during the meeting I did seek to record gaze, gestural, and postural elements that are essential components of the analysis of interaction (Goodwin, 2018; McDermott, Gospodinoff, & Aron, 1978; Stevens, 2012). I drew on an analytic procedure proposed by Pomerantz & Fehr

(1997): selecting sequences, characterizing the actions in a sequence, attending to "packaging" of actions and reference terms, noticing timing and turn-taking, and noting the importance of identities, roles, and relationships for participants.

Data & Analysis

Instructional logics in talk and practice

In this section, I show the ways in which each of the logics were present, to varying degrees, in statements made by Eagle Lake's administrators and teachers about their ideas and their professional practice. It is important to note first that the interview subjects knew I was studying the STEAM Lab, and the interviews opened with me asking them to reflect on the word "progressive" and what it meant to them. The picture of instructional practice that emerged was therefore skewed toward their associations with humanistic progressivism. A different image of Eagle Lake may have emerged if I had opened with questions about standards, testing, and traditional instruction. As the interviews went on (and as I posed open-ended questions such as "what is changing around here?") the interviewees shifted into reflections on the instructional environment at Eagle Lake as a whole. Broadly, the majority of the statements that I coded were within the essentialist, scientific, and humanistic logics. With this constraint in mind, I will now present this data and show connections with the logics as presented to this point in the study.

Essentialist. Despite administrators' identification of Eagle Lake as a "progressive" district, the school's everyday practices largely resembled those of most American schools, with disciplinary instruction organized by subject area and monitored by tests, quizzes, and papers. The middle school principal said that "there is more traditional [instruction] here than folks would claim." Even as administrators gave accounts and examples of "progressive" practice, they would routinely move to associate this activity with student learning of core academic subject matter. The principal at an elementary school in the district, Mrs. Carman, spoke rhapsodically about a recent activity in which students had constructed a vast amusement park in a multipurpose room: "the amusement park, it was kind of the epitome of all things, it was so great." What made it the epitome of all things, in her telling, was that it connected humanistic values (students were able to design the rides and attractions based on their own interests and creativity) with essentialist principles (each ride had a theme from world geography). She repeatedly gave standards-based justifications as a basis for the activity: "the number of standards that they're able to hit in this one project, four days intensive, was so amazing to watch." Asked why this was important, she explained:

> We're accountable for standards. We want good learning going on. Standards represent good learning in a lot of ways. Not that I think everything's perfect [about standards], but it gives us a path to follow, a skeleton to guide us. So we want to base everything on what we're trying to accomplish, what we're trying to learn. What are the standards we're trying to achieve? What do we, in education, believe is important for these students to know?

Mrs. Carman described valued learning outcomes in the activity as students understanding force and motion, and pointed to students' ability to bring in concepts from social studies as they explained why they had designed their rides in certain ways to represent different parts of the world. These justifications show the strong hold that the essentialist logic had within the professional environment at Eagle Lake.

Similarly, an assistant superintendent, Mr. Randall, described an activity he had observed in which students simulated their participation in a defense against a zombie apocalypse and at one point had to perform a zombie autopsy. Like Mrs. Carman, Mr. Randall was enthusiastic about this activity and associated it with what he called "that active problem-solving" and "active curiosity"—humanistic values and learning outcomes—but he also justified the activity with reference to disciplinary knowledge:

> Another fun [example of progressive education] that I saw the other day, where kids were doing zombie autopsies. That's what progressive ed is: zombie autopsies. What was neat about it is they were learning specific content. They were learning what the spleen would do, and what your lungs do, and your cerebellum, and cerebrum.

Like Mrs. Carman, Mr. Randall points to an essentialist assertion as the justification for this activity—"what was neat about it" was the connection with curricular content.

Administrators consistently spoke for the idea that teachers should guide and direct instruction. Another assistant superintendent, Dr. O'Bryan, contrasted Eagle Lake with what he called the "free school" model, citing A.S. Neill's Summerhill school (Neill, 1960). Although Dr. O'Bryan was strongly sympathetic to this model—he had used "Summerhill" as a working name for a small private school that he had started before coming to Eagle Lake—he also sought to distance himself from it:

> As a teacher, you have to have the wherewithal to know that you are accountable for a certain set of constructs that [students] need to know. There's some social studies, math, science that they have to know. … You have to learn all of those things. Ultimately, the teacher is the facilitator of the learning. It doesn't mean the children run the classroom. The teacher says, "Okay, I see that you're having trouble with this right now at this moment, but it doesn't keep you from being accountable for it. Eventually, you need to demonstrate to me that you know the characteristics of a neighborhood or something like that." You're still in charge of and you hold children accountable what they need to learn, because you're responsible for that.

Although an in-depth study of Eagle Lake's predominant instructional practices—i.e., the classroom activities that took place the school outside of the STEAM Lab—was not within the scope of this study, I did observe math and science classes. On the day I observed a 7^{th}-grade science class, the topic was solubility. At one point, the teacher asked what would happen when solubility decreased. Using the technique of the known-answer question (Mehan, 1979; Macbeth, 2003; Cazden, 2001), she sought to elicit the word "precipitate":

Teacher: What word would I like to hear?
[After a long pause, one student raises his hand and is acknowledged.]

Andrew: "Pedicure"?

Teacher: No, not that. I want to hear what word?
[Long pause.]

Paul: "Precipitate"?

Teacher: Yes!
[Paul high-fives his friend.]

Later in class, the phenomenon came up again. The teacher posed the question:

Teacher: Imagine that I'm looking at a test tube of a saturated solution at X degrees and it's cooling. Joey says nothing will happen, I am arguing that something will happen.

Theo: It will regenerate out.

Teacher: Use the word 'precipitate'! Normally I'm fine with whatever you use, but please use the word 'precipitate'.

Theo: The solute will precipitate out.

Asked about this exchange after the class, the teacher explained:

> Usually, I'm fine if they describe something without using vocabulary, but in this case I wanted them to use the scientific vocabulary. I want to be sure that they are using correct science communication.

This episode was, of course, unremarkable—an ordinary "school" moment—and almost certainly representative of the broader moment-to-moment instructional practices at Eagle Lake. The teacher's search for "precipitate" represented an everyday example of the essentialist program for science instruction. Whether in the context of justifying innovative practices such as a zombie autopsy or in everyday traditional teaching, the essentialist logic was consistently present in professional discourse and practice at Eagle Lake.

Scientific. District leaders reported that they experienced strong pressure from the school board and the community to demonstrate measurable student growth. Mr. Randall, an assistant superintendent, reported that "school boards, including our own, put immense pressures on schools to move a certain number." The drive to produce what the superintendent Dr.

Karlssen called "evidence of learning" was an overriding concern for the professional staff at Eagle Lake, and there were a wealth of quantitative measures—especially state tests—to produce such evidence for the essentialist program. But Dr. Karlssen reported that she struggled in her communications with the board to describe the outcomes of the district's experiments with humanistic instruction:

> We all can go into an environment [where alternative instructional approaches are in place] and listen to kids and know that it's a good thing. We feel it. You can talk to kids and hear what they have to say, but how do we communicate that?

Dr. Karlssen alluded to tensions with some Eagle Lake educators who were resistant to measurement. Referring to McHenry's century-old efforts to develop research-based instructional practices, she noted that "data seems to be a four letter word with our staff here sometimes, but [historically] we were built upon data." The word "data" was significant to an assistant principal, Mr. Swanson, who like other administrators spoke about pressure placed on the Board from parents seeking ever-increasing amounts of measurement:

> There's a 'data monster' in the community. Quantitative data is so important … it has to guide our instruction. It has to guide how we are looking at programs that we've implemented, and whether or not they're successful. But sometimes there's an over-reliance on this quantitative data. And it becomes this sole driver to some parents. I mean, you go to some Board meetings and it's, like, such a huge concern.

The pressure to quantify Eagle Lake's essentialist program was not limited to test scores measuring progress in school subjects. The district had licensed a study survey tool called the 5 Essentials. Most of its questions involved survey items related to essentialist teaching practice; for example, students were asked to report how often they had been asked to explain their thinking during math problem solving. Administrators used similar tools in an effort to quantify their reform initiatives. The technology director, Mrs. Schwartz, explained how she had decided to purchase another survey tool, the BrightBytes survey software:

> BrightBytes came on board when we were starting our mobile learning initiative, which is one to one iPads for grades 5-8 [and wanted to know], how are we going to measure it? There's not many places that have measures for these things that are quantitative, not qualitative.

This survey tool would later be used in the STEAM Lab, with students asked to self-assess on questions like whether they had improved on "21st century skills."

Humanistic. As defined above, the humanistic logic attends to the freedom, interests, needs, goals, and personal development of the learner. Tech21, along with another makerspace in the district, was the primary context in which these values were translated into practice. Accordingly, the two STEAM/makerspace teachers I interviewed, Mr. Jacobson and Mrs. McDonnell, spoke most strongly for the idea of student freedom and creative expression.

> What I like about my space here is that it totally is student choice. .. Just having the space for them to come in and be able to choose and learn. Sometimes it feels like a free-for-all, but I like the idea of them coming in and being able to decide what they want to do and run with it. I find there are some kids who are ironing beads, but there are others who are building drones. Now I don't know if they are going to fly, but they sure are excited and they sure do try and they, they'll do different things, they'll research, they'll try again, and they never seem to get discouraged. *Mrs. McDonnell*

In this passage, Mrs. McDonnell draws a direct parallel between students' ability to choose ("to decide what they want to do and run with it") and their development of personal qualities of resilience and adaptive problem-solving ("they'll do different things, they'll research, they'll try again, and they never seem to get discouraged").

Mr. Jacobson argued for curricular initiatives, such as Tech21, that were "for" the students themselves, a humanistic assertion about the purpose of education:

> As a teacher, what we should be doing is we should be teaching for the students, and we should be creating programs for the students and the learners, not the adults. So when I have many students come in here telling me that this is their favorite classroom or this is their favorite class and they love being in here, that to me speaks volumes. That's one way I feel like I know that we're doing the right thing. *Mr. Jacobson*

Mr. Jacobson's conception of measurement—how Eagle Lake would "know that we're doing the right thing"—involves student self-reports as to their favorite class. Notably, although the

BrightBytes survey tool was ostensibly intended to capture student perceptions, Eagle Lake set the tool up so that it was instrumented around the goal of "21st century skills," a term which during informal conversation with students I determined that many did not understand. With its Likert-style quantification of agreement with fixed questions, the survey tool did not allow space for students to state, as they did to Mr. Jacobson, that Tech21 was their "favorite" class or to say that they "love being in here."

The distinction between the choice-based environment of the STEAM Lab and the essentialist program elsewhere in the district was reflected in tensions that Mrs. McDonnell and Mr. Jacobson described, in which other faculty questioned activities that involved choice and creativity. Mrs. McDonnell, the STEAM teacher who had been involved with her school's free-choice "genius hour", reported:

> Now with this extra period that we have at the end of the day, that's been, for me that's easy, because that's what I *do*, I'm the makerspace facilitator. But for a lot of these teachers the thought of giving up that control—even in a progressive situation—the thought of giving up that control and saying to the kids "you choose what you want to do," that's hard for them.

Here, Mrs. McDonnell asserts that what is problematic for the teachers, even in a "progressive" context like Eagle Lake, is the transfer of control from the teacher (as envisioned in the essentialist logic) to the student (as envisioned in the humanistic logic). She went on to tell a story in which a veteran teacher had observed her class:

> I had a teacher, he's been in the district as long I have—he's an excellent, excellent teacher, one of the best. Again though, the control, it's hard for them to give up the control. … When he was describing what we did at our faculty meeting, he said basically the kids just played. And they did and that's true, but I think he saw that as *all* play and did not even see that they were engaged, they were working in groups. There was no one who was just standing.

Goodwin's (1994) concept of "professional vision" may be usefully applied to this passage. Professional vision involves "ways of seeing and understanding events that are answerable to the distinctive interests of a particular social group" (Goodwin, 1994: 606). The colleague's assertion that the kids "just played" suggests that when he observed her class, he was looking for evidence that the activity was producing academic growth, e.g., scientific principles of force and motion. These were the particular interests of the group for which this colleague spoke: the teachers tasked with carrying out Eagle Lake's essentialist program. Mrs. McDonnell acknowledges that the students were experiencing this activity as play—"they did and that's true"—but asserts that the colleague "did not see" what she valued: engagement. The other teacher did, of course, see the engagement, but what Mrs. McDonnell is arguing here is that her colleague's professional vision involved a way of understanding the activity that did not align with the expectations of his social group. The phenomenon of "engagement" (what Kilpatrick [1918] called "wholehearted purposeful activity") has a positive valence within the humanistic logic that it does not within the essentialist logic, which accounts for the different types of "seeing" in Mrs. McDonnell's account.

The professional staff associated choice-based activities with valued learning outcomes involving personal skills such as adaptive problem-solving, resilience, teamwork, communication, creativity, leadership, and self-direction. The term "the 4 C's" (referring to communication, creativity, collaboration, and critical thinking) was commonly used as a shorthand for these skills; teachers and administrators also used the terms "21st century skills" and "soft skills" (which the superintendent described to me as "the hardest ones kids can learn right now"). Providing students with opportunities to make decisions and pursue goals was often referred to as "voice and choice". The most common invocation of these ideas occurred when teachers and administrators mentioned a specific activity and associated it with 21st century skills or the 4 C's. Mrs. Carman elaborated on her view of the amusement park project, in which students had been given substantial latitude to design their own rides and attractions:

> The collaboration, the creativity, the leadership that some students were showing that normally don't. … The energy that the students came with was unbelievable: “This is the best week of school ever!" They were so excited.

Mrs. Carman, like Mr. Jacobson in the passage quoted above, values the students’ perception of the experience (“the best week of school ever”). This emphasis on student concerns is central to the humanistic logic.

Vocational. In comparison to the essentialist, scientific, and humanistic logics, there were significantly fewer invocations of vocational claims: the notion that Eagle Lake should prepare students for the job market, or that the education that Eagle Lake provided was connected to the national economy. Mr. Randall was one of the few who spoke for this view, arguing that the use of high-tech tools such as those found in the STEAM Lab would help students in their careers:

> It's important that students know to use these new tools, and have some fun. Even if they're not going to become computer programmers, to familiarize themselves with those languages because those are languages that are going to be spoken. Already we're seeing that people in the workplace—it doesn't matter where you work at, you could work at a theater company, you could work for a law firm—people that have that skillset have a distinct advantage in the environment over their colleagues.

In these observations, Mr. Randall asserts that learning to code would prepare students for their careers regardless of whether they become programmers. However, he connects this skill with a competitive logic: students would “have a distinct advantage” over others. As described below, this view of education as advancement over other people was widely ascribed to parents but rarely spoken for by the professional staff.

Another administrator who spoke for this view, the assistant principal Mr. Swanson, asserted:

> See, education, in my mind, isn't just about the academic standards. It's about these are young people who are going to be … members of a workforce. They're going to be bosses. They're going to be leaders. And they need to have exposure to skill development that goes beyond your typical classroom setting.

Echoing themes of his colleagues, Mr. Swanson saw training for the workforce not as narrow skills (e.g., coding) but also as the development of 21st century skills:

> In order to prepare a child for the workforce or higher levels of learning, we need to expose them to radically different types of learning, because we have no idea what the workforce is going to look like five years from now much less ten, much less fifteen or twenty. So what we need to do is we need to give, get them used to collaboration, creation, solving problems that don't even exist yet in some ways. Giving them ownership of their learning. The confidence that comes from something like this. The confidence that comes from a kid researching their own thing, creating their own thing, coming up with their own solutions will carry over well past high school.

The “four C’s”, then, were deployed not only in connection with humanistic goals—the idea that development of creativity and collaboration skills would follow from the freedom to pursue interests—but also the vocational logic.

Democratic and social reconstructionist. My first interview at Eagle Lake was conducted with assistant superintendent Mr. Randall. Responding to my opening question—“what is progressive education?”—Mr. Randall responded:

> Well, it's interesting. I just reminded our superintendent, this is the 100th year anniversary of Dewey's *Democracy and Education*, which I always keep a copy of. This summer I made sure I reread that.

Mr. Randall’s associations with this text, however, did not extend to Dewey’s (1916) vision of education as performing a socializing function for participation in a democratic society and the responsibilities of citizenship. Instead, like other administrators and teachers at Eagle Lake, he focused instead on the more popular and conventional reading of Dewey’s work as calling for learning through participation in practical activity: “What we do know is that people learn through experiential opportunities. It’s this idea of learning by doing.” Only Mr. Randall’s colleague, assistant superintendent Dr. O’Bryan, actively spoke for democratic principles. He first related a series of anecdotes drawn from his experience as an elementary school teacher in which he had allowed students decision-making authority in class governance and in their participation in class projects. He also associated democracy with “student voice”:

> Progressive education for me is … really there's a few components, but democracy I think is one of the biggest ones because democracy includes student voice. To me, the excitement of students coming to Eagle Lake … is students skip to school not because, "Oh, we're going to do the TV studio," but "The TV studio program is going to be created out of my input and using my voice, and my collaborative work with my peers. My identity is being formed as I go to school. Not because of someone telling me what to do and what to learn, but because someone is honoring my voice and my perspective and nurturing my capacity as a citizen."

With rare exceptions, interviewees in the extremely wealthy community of Eagle Lake did not introduce notions of social reconstruction, the idea that education has a role in creating a more just and equitable society. The superintendent, Dr. Karlssen, hinted at this view as she summarized Eagle Lake's history:[15]

> The community came together early on and said, "Hey, we want to be different. We want our kids to learn in a very meaningful way. We like what these progressive folks are saying about kids not being vessels, but truly being engaged in their learning, based on the work of Dewey." So they searched wide and far, found a superintendent they felt that was aligned with that philosophy, Alexander McHenry, brought him here, and said, "Let's build our school system around kids being actively engaged." And we wanted to develop citizens in our democratic environment here that are truly going to help this world. I don't mean to be so grandiose, but I truly believe that's what drove this community to engage and commit so much to its schools.

Eagle Lake's modern-day students did participate in many charitable and social outreach ventures to "help this world", including substantial fundraising for a local children's hospital and efforts to support artists in Central America. Other than Dr. Karlssen, however, only the STEAM Lab teacher Mr. Jacobson spoke explicitly of social change as a goal:

> I think one of the reason that I like being here in Eagle Lake, especially being from the city, is that you see so many students here whose parents are leaders of industry, influential men and women, successful. ... I taught at a Catholic school and I went to [a Jesuit] university where a lot of it was giving back and social justice, I think one of the ways that I could give back here is to help these future leaders who are in these high positions. With their successful parents, and connections, and

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[15] Dr. Karlssen here relies on McHenry's own account of his recruitment to Eagle Lake, as told in the memoir that she kept on her desk and frequently consulted. As described in Chapter 1, however, McHenry's story of having been discovered by community leaders conducting a national search for a Deweyan leader is dubious; family connections likely brought McHenry to Eagle Lake's attention (Schumann, 1970). In her critical dissertation, Schumann (1970) instead asserts that Eagle Lake school leaders never cared about the "progressive" practices and instead sought to align their community with what would today be called the progressive "brand" so as to attract fashionable, wealthy families. In Schumann's (1970) account, McHenry simply gave the wealthy families what they wanted: training for elite boarding schools along with the prestige of associating with progressivism. Although Schumann's (1970) representation is overdrawn—documents show that Board members were in fact drawn to experiential and hands-on learning—there is little evidence that under McHenry's leadership, Eagle Lake schools pursued charitable initiatives in the way they do today.

> things that I feel that they're going to have, if they can remember giving back and trying to solve problems, and not just doing it for profit, but to make the world better. I know that sounds kind of cheesy, but I really feel that these young people have a little bit maybe of a step up. If your colleagues and maybe your dad, or family member, or people that you know who are CEO's of companies, and they are people that you look up to, and you can combine helping the world with these high positions of power I think that's going to make this a better place.

Mr. Jacobson here inverts the competitive logic that is described below. Surveying Eagle Lake's community of already-advantaged families who "have a little bit of a step up," he sees his role as a teacher as coaching the students who will ultimately hold "high positions of power" to "make the world better."

Competitive. No administrators or teachers spoke for a view of education at Eagle Lake as a credentialing system for personal economic and social advancement of individual students. Attributions of this view to parents in the community, however, were widespread. In particular, administrators continually brought up a recent incident in which a group of activist parents had obtained and analyzed test score data and complained to the Board that the schools were not serving their children.

> I came in [to this job] and I saw it was a little bit of a hot mess. I walked into a situation where parents were actually creating their own assessment reports, if you will, and sharing those at the house, and sharing those with young parents. It's hard to be a young parent in the modern age because there's a lot of information. If you're not doing this starting with Baby Einstein at three-months-old, your kid's going to end up poor and lonely. It's hard being a parent in this particular day and age. *Mr. Randall, assistant superintendent*

> I have some parents who just want the numbers. … "What does that mean for my child?" "How do I keep up?" "How do I compete?" When we talk about these great learning experiences, they don't want that. It's "Is my child better than the rest of the group?" They all want their kids to be the top performers. *Mrs. Carman, principal*

In these quotations, we can see that the competitive logic served to reinforce the scientific essentialist program that was pervasive in the school. Parents who "just want the numbers" were "creating their own assessment reports" and using them in meetings to organize advocacy groups that would call for ever-increasing focus on direct instruction. The superintendent shared her theory that this view was particularly common among parents who worked in finance:

> Those in our community who are the bankers, the hedge fund [managers], and things like this … it's really the quants. It's really hard sometimes to convince them. Because it's about having the edge over the others. Unless you can show the edge in a quantifiable way how it's going to impact [their children] in their career, it's very hard to convince them [about progressive methods].

The perceived need to "show the edge in a quantifiable way" made it harder for the professional staff, who lacked a statistical language to represent that "edge," to make the case for humanistic practices.

Summary. In this section, I documented the presence of 7 instructional logics at Eagle Lake. The predominant logics—pervasive in the accounts given by administrators and teachers, and observed in my classroom observations—were essentialist, scientific, and humanistic. The professional staff also spoke for vocational perspectives and for democratic conceptions of instruction. Only two interviewees mentioned social reconstructionist views, and then only in passing. Competitive views were exclusively attributed to parents, although the many references to these views by district leaders attested to the influence they had. In the next section, I show that Mr. Jacobson's Tech21 class in the STEAM Lab was justified to the Board using a blend of essentialist and humanistic arguments, but was implemented using a combination of humanistic and scientific logics. After this section, I use the interactional institutionalist approach described above to present an incident in which the essentialist and humanistic logics were mobilized during a debate over access to a scarce resource: time in the STEAM Lab. The chapter closes with an analysis of how the logics were stabilizing at Eagle Lake.

Establishing the STEAM Lab

The Tech21 class in the STEAM Lab represented a distinctive change in instructional practice from Eagle Lake's scientific essentialist program. Before describing how this came about, I will describe how the Tech21 class was different than other electives. The difference is critical but subtle and indeed was not even clear to many on the staff at Eagle Lake, especially to those who taught elective classes that, like Tech21, also included hands-on, constructive, and creative activities.

STEAM Lab as a site of freedom and choice. The fundamental distinction between Tech21 and other electives involved the extent to which freedom was granted to students. Mr. Jacobson, the Tech21 teacher, reported that many of his colleagues on the elective staff, when learning about his class, would assert, "we're already doing that," a common reaction to reform practices (Spillane, Reiser, & Reimer, 2002). However, Mr. Jacobson drew a sharp distinction between his class and the activity structure of the other electives, echoing Kilpatrick's redefinition of "project":

> In the other classes, the teachers think if you're using your hands, you have a project. We are taking it one step further, saying *you* choose the project. For them, it's not full interest-based … there are more guidelines. … [Here] you are doing interest-based, exploratory, and at the core of it is choice, you're figuring out problems on your own. [In the other classes, it's] "here is a project, follow the recipe." We're focusing on the four C's—life skills and problem-solving and creativity and critical thinking.

This distinction between hands-on activity and the additional presence of an activity structure of freedom and choice could be seen in the course descriptions of Tech21 and a class that on the surface appeared similar, Industrial Design & Engineering (*see* Figure 2). While both classes involved design and construction, Mr. Jacobson's description emphasized choice and learner control while Mr. Watley's description noted that "students will be posed with a variety of problems to solve" and did not refer to choice.

INDUSTRIAL DESIGN & ENGINEERING 7/8
[Mr. Watley]

For students who like to be challenged, this class is for you! ***Students will be posed with a variety of problems to solve*** *in the areas of industrial design, engineering, and architecture. This is not your typical "shop" class. While some time will be spent constructing projects from a set of plans and building other mechanical devices, class time also will be used to learn CAD (computer aided drafting), design floor plans for a house, and learn about electronics. If you think you are an idea person, then join the IDE team.*

TECH21 7/8
[Mr. Jacobson]

Are you innovative? Do you like to design and create? Then TECH21 is for you! ***Choose from a variety of projects or create your own. In TECH21, you are in control of your learning.*** *This course is designed to engage and challenge students of all abilities through hands-on, minds-on projects focusing on real-world, 21st-century career-ready skills. With design thinking at the heart of this course, the authentic student-driven curriculum incorporates STEAM, technology exploration and digital media arts through project-based learning. This student-centered class adapts to different abilities and learning styles.*

Figure 2. Course descriptions for the Industrial Design and Tech21 electives.

This distinction, while obscure to some teachers, was clear to students. In a comment that echoed an account I heard from many students, 7th grader Robby explained:

> In Tech21 you get to be yourself and get to be free, under a set of guidelines. You get to set out and choose … you get a more free experience and you get to solve it for yourself. There are problems there is no answer to. It's what's in your heart and what you desire, it's your goal.

7th grader Kira, whose story is told in Chapter 4, reported:

> This class has challenges that I *want* to do. I wouldn't like to challenge myself to a really hard math problem, but I *would* challenge myself to figure out how to design something and print it. It's [a class where] you can be free and do what you want and have no one say, "OK, here's your assignment, here's what you have to do." It's more like, "Here, we have everything here and you decide what you want to do, and you decide how you're going to do it, and it's going to be hard, but you're going to try to figure it out."

Authorizing the STEAM Lab. The move toward the critical additional element of a choice-based activity structure had been orchestrated by Mr. Jacobson and Mrs. Schwartz—working with the implicit approval of the leadership team—in an example of institutional entrepreneurship (DiMaggio, 1988; Battilana, Leca & Boxenbaum, 2009). Dr. Karlssen, the superintendent, arrived at Eagle Lake for the 2014-15 school year, and one of her first acts was to recruit Mrs. Schwartz from a neighboring district to serve as technology director. Dr. Karlssen and the Eagle Lake school board worked out an "entry plan" in which she met with students, faculty, parents, and community members. Hearing repeated invocations of the term "progressive education" and references to its history at Eagle Lake, Dr. Karlssen then produced and circulated a one-page document that she called "Progressive Education Definition" (*see* Figure 3). In this document, Dr. Karlssen associated progressive education with ideas about students owning their learning, advocating for themselves, making choices, experiential learning, and project-based methods.

Progressive Education Definition

Students …

Own their learning and advocate for what they need
Reflect on learning
Make choices based on interests and relevancy
Collaborate and share responsibility in democratic ways
Live and experience the curriculum
Critically think about the world
Show what they know in authentic ways
Learn skills and apply ideas
Extend their learning with extracurricular opportunities

Teachers …

Emphasize the whole child in planning
Collaborate with one another to continuously improve learning
Develop a sense of community within the class, school, and greater community
Provide flexible learning environments
Integrate content areas/units/experiences to make the learning meaningful
Act with autonomy in response to learners' needs
Gather meaningful information/data to deeply know each child & the curriculum

Curriculum …

Emphasizes experiential learning and project-based methods
Demands interdisciplinary connections (content areas & social/emotional areas)
Fosters collaborative, authentic learning experiences
Embeds service learning
Builds relationships among ideas, others, and the outside world
Stretches students' thinking and provides challenging dilemmas worth engaging

Figure 3. Dr. Karlssen's interpretation of the term "progressive," based on her conversations with Eagle Lake faculty and community members.

Dr. Karlssen also prepared a memo, delivered to the Board in January 2015, summarizing ideas she had heard during these entry plan meetings. She wrote of "a desire to incorporate STEAM" and "a desired target on innovation, creativity, critical thinking, and collaboration." She also contrasted a "desire to identify mechanisms for verifying, via evidence, that all students are growing" with a view that "success means more than just high test scores." In this memo, she reported that STEAM would be a priority: "An analysis of technology and curriculum strategic goals will be conducted to determine the best avenues for embedding STEAM learning in our schools." Later that year, she defined "STEAM" and "21st Century Experiential Learning" as 2 of 7 priorities for the district, and requested and received a $216,000 budget allocation for "STEAM Pilots". An old science lab was remodeled and equipment purchased for what would become the STEAM Lab, and Mr. Jacobson, a technology coach, was appointed to teach the Tech21 class for the 2015-16 school year.

Institutional entrepreneurs are "skilled actors … who can draw on existing cultural and linguistic materials to narrate and theorize change" (Garud, Hardy & Maguire, 2007: 962). A centerpiece of this strategy by Eagle Lake administrators was the use of the terms "STEAM" and "21st Century learning" in the communications made to the Board. These terms circulated widely in the educational discourse of the mid and late 2010's, lending increased legitimacy to requests attached to them. Both terms had the advantage of carrying no specific pedagogical implication. STEAM, in particular, allowed hearers to recognize in it their preferred logic: as an acronym for science, technology, engineering, arts, and mathematics, it seemed to carry essentialist connotations; with connotations of hands-on, maker-oriented learning, it engaged the humanistic logic. In what follows, I trace the use of this term in administrators' communications to the Board during the period in which the STEAM Lab was being authorized and then stabilized.

Defining STEAM: From scientific essentialist to humanistic justifications. Different representations were made regarding "STEAM" in a series of memos to the Board in 2015 and 2016 as Tech21 was proposed and then augmented by the addition of the FUSE Studio (Stevens et al., 2018, 2016). These representations served to legitimize and then solidify the program by connecting it with a vocabulary (Erickson, 2004) that would be persuasive to the Board.

STEAM was first depicted in early 2015 using language from the essentialist logic: STEAM was defined as "an approach to teaching and learning that integrates the content and skills of science, technology, engineering, arts, and mathematics" (Eagle Lake Board of Education, 2015). This essentialist claim ("content") was supported with a scientific assertion: in a mid-2015 memo authored by Mrs. Schwartz, the Board was assured that quantitative data would be used to measure the program through the BrightBytes survey platform. However, it was not until late 2015, after Mr. Jacobson had been hired and had established the Tech21 class, that the theme of choice first appeared in the memos written for the Board. One such memo asserted that, "As you experience STEAM in K-8 [in the district], you see a gradual release by grade level from teacher-directed to student-directed, with student voice and choice being valued throughout" (Eagle Lake Board of Education, 2015). Here, STEAM began to be connected to the theme of choice, a subtle but critical shift. Mr. Jacobson's appointment and support from Mrs. Schwartz was critical to the choice-based model. He later reflected on the move to instantiate choice:

Peter: *How did it come about that Tech21 was about choice?*

Mr. Jacobson: [In previous tech classes] I thought I had cool projects, but the kids didn't seem into it. The freedom to choose something that interests the students gave them that instant engagement. … So I asked that [Tech21] be my project. I wanted to do this because of the choice and student interest.

I interpret these developments, culminating in Mr. Jacobson's appointment and his implementation of choice, as a series of entrepreneurial moves by Dr. Karlssen and her team. She strategically framed the new initiative using language that hinted at both essentialist and humanistic logics, giving cover to her team to implement the STEAM Lab the way they saw fit. Once the time and space had been allocated, Mr. Jacobson, with support from Mrs. Schwartz, was free to install the activity structure that they believed in.

At this point (spring 2016), FUSE Studio (Stevens et al., 2018) entered the picture. Although the defining characteristic of FUSE from the standpoint of the program designer was its choice-based nature (Stevens, personal communication, 2016), its role in helping to solidify the Tech21 actor network was multifaceted. In interviews and informal personal communications in spring 2016, Mrs. Schwartz reported that she first encountered FUSE in an email promoting an unrelated university-based professional development program. She browsed the FUSE website and concluded that FUSE "aligned with the way we were currently doing business" in Tech21, which she described as allowing students to "choose a topic of interest." However, she had become concerned that the extent of choice in Tech21 class meant that it had come to lack sufficient organization, and she sought a program that would provide increased structure. The designed challenges of FUSE, with their video-based tutorials and "leveling up" progressions, provided this structure and Mrs. Schwartz believed they would improve the cohesiveness of Tech21. Moreover, the association of FUSE with a prestigious research university, Mrs. Schwartz noted in an interview, gave legitimacy to the choice-based model. Accordingly, in the fall of 2016, Mrs. Schwartz reported to the Board the acquisition of FUSE Studio, mentioned its connection to the university, and justified it by asserting its connection to what she called the Tech21 model of "experiential learning through student choice driven activities" (Eagle Lake Board of Education, 2016). FUSE thus served to stabilize Tech21 internally within the school (by reassuring Mrs. Schwartz that the choice-based model had some structure) and externally to the Board (by reassuring the Board members that the choice-based model had the imprimatur of university research). By April 2017, Mrs. Schwartz reported to the Board (Eagle Lake Board of Education, 2017) on favorable comments she had received from delegations of visitors from other schools who had visited the STEAM Lab, choosing to highlight remarks that pointed not to STEAM content but to choice, independence, and student interest:

> "There is so much choice for students!"
>
> "The students were very focused and independent. Student agency was evident and great to see."
>
> "LOVED it! What a creative space! The students were working together, enjoying what they were doing, being innovative, and learning. This is a class that should be at every school."

In summary, the administration justified the STEAM Lab to the Board using essentialist and scientific logics: it would facilitate learning of "content and skills" of science, technology, engineering, arts, and mathematics and would be measured using quantitative survey data. The language used to characterize the proposal recalled a system of meaning that promised consistency with the district's longstanding practices (Campbell, 2004), and the presence of a quantitative survey instrument assured the Board that there was a monitoring mechanism (Scott, 2008) that would translate activity into visible measures. Once the STEAM Lab had been established, however, Mr. Jacobson—consistent with Dr. Karlssen's view in her Progressive Education Definition that teachers should "act with autonomy in response to learners' needs"—implemented a choice-based activity structure. FUSE served to improve Tech21's legitimacy by providing what Mrs. Schwartz interpreted as increased structure and what the Board, conversely, was meant to understand as a university-sanctioned program of increased choice. Mrs. Schwartz and Mr. Jacobson thus acted as institutional entrepreneurs to instantiate the core of humanistic logic in an Eagle Lake classroom: learning connected to freedom, interest, and personal development.

The Contest for the STEAM Lab: Logics in Interaction

The interviews presented above showed the ways in which the various logics were present in administrators' and teachers' accounts as they reflected about Eagle Lake with a researcher and in everyday practice in an Eagle Lake classroom. I then showed how the humanistic logic came to be strongly present in the STEAM Lab: authorized by the Board under more traditional justifications, the class that Mr. Jacobson and Mrs. Schwartz ultimately designed focused on creative expression and freedom of choice. This move was not without controversy; Mr. Jacobson and Mrs. Schwartz each reported that other teachers were jealous of the resources allocated to the STEAM Lab. Mr. Jacobson often mentioned that this tension had extended to him personally and that he felt isolated by his colleagues: "It's hard … people stop talking when I go into the teacher's lounge" (Interview, 2017).

I now locate the logics "in action" as they were spoken for and contested by participants at Eagle Lake during a tense negotiation over a limited resource: access to the STEAM Lab. In what follows, I present a moment-by-moment description of a meeting on March 21, 2017, in which the science department chair advocated for Science Wizards, a science enrichment program he coached, to be included in the Tech21 class in the STEAM Lab.[16] In this meeting, Jim Reilly, the department chair, spoke for the essentialist logic, making arguments grounded in disciplinary math and science. Eddie Jacobson, the STEAM Lab teacher, spoke for the humanistic logic, arguing for "21st century skills," "design thinking" and "voice and choice". This meeting represented an important, concrete moment in which logics came into conflict over access to the STEAM Lab. Mr. Reilly's argument for Science Wizards entailed a particular accountability: the "testing events" that were a requirement of participants in the Science Wizards program.

[16] It is not clear how many such meetings took place; my study design did not call for observation of staff meetings. This meeting took place in the STEAM Lab itself during an open period on one of my observation days.

Mr. Jacobson had communicated to me that Mr. Reilly had requested a meeting to discuss the matter. I asked if I could attend and Mr. Jacobson agreed. At the meeting, I introduced myself to Mr. Reilly, explained the research, and asked if I could observe. He agreed and signed a consent form. Carol Schwartz (the district's director of technology) also agreed and had previously provided consent. I audiorecorded and transcribed the conversation.

The discussion opened with Mr. Reilly physically oriented toward Mrs. Schwartz, rather than Mr. Jacobson, and directing his gaze toward her. He maintained this orientation for most of the conversation. To start the conversation, Mr. Reilly recalled his experience coaching Eagle Lake's Science Wizards team at a recent tournament. Science Wizards tournaments, in the organization's description, are "rigorous academic interscholastic competitions" that include "challenging and motivational events … well balanced between the various science disciplines of biology, earth science, chemistry, physics and technology … there is also a balance between events requiring knowledge of science concepts, process skills and science applications" (Science Wizards web site). Throughout the conversation, Mr. Reilly focuses on the construction activities ("building events") that are part of Science Wizards.

Mr. Reilly: I guess I e-mailed you guys, and I've talked to Eddie, and I always stop in here and I throw ideas off of Eddie, and I was just at the Science Wizards Regional Competition. There are so many Science Wizards events that are just so ... they're just *made* for this classroom. I don't want to tell Eddie how to run his class or anything, but being able to incorporate some of these projects as options … would be a really good idea. Not only that, it would help us out as a Science Wizards program, having these kids spend more time building these projects because we ... It's hard, it's hard, given the amount of time to build these.

Mr. Reilly opened here with an assertion regarding the alignment of Science Wizards with what he asserted would be an appropriate use of the STEAM Lab: the building events, in his telling, are "just *made* for this classroom." He framed his approach deferentially—"I don't want to tell Eddie how to run his class or anything"—although this unprovoked denial (Fink, 2011: 41-42) indicates that he sensed that his request could have been interpreted by Mr. Jacobson as an imposition. Mrs. Schwartz encouraged Mr. Reilly to continue.

> **Mrs. Schwartz:** Can you give me an example of a couple of things [from Science Wizards]?
>
> **Mr. Reilly:** Yes. A few of the building events would be like *Mission Possible*, which is a lever-based event. They have to know about simple machines and they have to build a simple machine that does 18 switches, and [gesturing] the ball has to start from here, and actually there's parameters. It's an engineering and a science based event. The ball makes 18 different transfers and activates all these different simple machine mechanisms. … Then there's *Scrambler* where you have a car that you have to build … the car has to stop in an unknown amount of meters. [Gesturing throughout] They have to be able to stop the car within eight to 12 meters. They have to be able to have a stopping mechanism that they can actually move and adjust to that specific length. This year, they had a big obstacle in the middle. Your car actually had to go around it. **They were using angles. They started making angle sheets. This is where the math comes in and the little bit of geometry and trig, but they had to know at what specific angle where the object was located and how to get the car around it** because they needed to get it in front of this board and they had an egg on the front and they couldn't smash the egg. It had to stop.
>
> **They're very difficult projects. There's a lot of math, and there's a lot of science. If this is a STEAM lab, I think a lot of what I see is there's not a whole lot of science and math being done.** And that's why I said I wanted to get incorporated into the STEAM lab.

Here, Mr. Reilly introduced an argument to which he would return repeatedly throughout the conversation: he assumes consensus on the principle that "math" and "science" are worthwhile goals; that since the room is called the "STEAM Lab," it should include "math" and "science"; that Science Wizards includes "math" and "science"; and that the solution to this was for him to "get incorporated into the STEAM Lab," a change in the school's routine and rules. He used a story about Science Wizards participants doing an engineering challenge and specified that "this is where the math comes in," seeking to strengthen his hearers' association between Science Wizards and "math." When Mr. Reilly says that "a lot of what I see" in the STEAM Lab is "not a whole lot of science and math," he excludes the applied, emergent mathematical problem-solving that will be shown in Chapter 3. This problem-solving typically involved application of lower-level math concepts such as simple problems of proportion and scale. Mr. Reilly either did not notice this work in the STEAM Lab or did not "count" it, a phenomenon that Stevens (2000a) called the "institutional invisibility" (134) of emergent, applied math.

Mr. Reilly's argument was based on an appeal centered on the term *STEAM* (an acronym for science, technology, engineering, art, and math) as the agreed-on characterization of the space. In so doing, he established a baseline for subsequent discussion—that the discussion is about the "STEAM Lab"—which enabled his constructs of "math" and "science" to be seen, by association, as authorized activities in this space. This move to claim STEAM as the basis on which the conversation will proceed serves to "constitute the frame of relevance that will shape subsequent action" (Pomerantz & Fehr, 1997: 289). A few minutes later in the conversation, however, Mr. Jacobson will acknowledge but try to block Mr. Reilly's move by redefining the space toward two different constructs, "design thinking" and "21st century skills":

Mr. Jacobson: **I know that we're STEAM, but really as this has evolved I feel that it's more design thinking and 21st century skills** is really how this class, or program, is morphing and growing. That being said, there's room for that STEAM too. We can take the design thinking and take these challenges and put them out there and then see that development through that science and math lens where we're even hitting that [core academics] maybe a little bit harder, I guess, right?

Mr. Reilly: Absolutely. I think just from an outside perspective, I think the design process is definitely all there, and that whole process is evident, but then **when you look at what's being done I think it's more or less the T part of STEAM, and the science and the math and the engineering is not as big as the tech part**. The design thinking is absolutely there. That whole process that you want them to go through is there, but it's mostly centered around the technology aspect of it. There's nothing wrong with that, but I would love to come in here and see ... That's why I'm saying I can lend my expertise into science, and I'm pretty good at math, and I can do that, and engineering I'm pretty decent at.

Mr. Reilly here accepted Mr. Jacobson's bid to introduce "design thinking" as a component of the space, but pointedly ignored his invocation of "21st century skills" and shifted the conversation back to a reiteration of STEAM and its association with disciplinary "science," "math," and "engineering."

Mr. Reilly closed his initial appeal by pointing to support he had already secured from a school administrator for a change in a teacher's schedule:

Mr. Reilly: I don't know how it would look. **I talked to [assistant principal] Jack yesterday** just to let him know I was talking to you guys. **He's all for it. He's like, "You know, if you have to give up advisory and give up a flex thing," but he's like, "Yes, I think that's a good idea."**

I just think having science in here--it doesn't have to be me, or it could be anyone—but I think it'd be awesome.

The conversation then turned to the rules Mr. Reilly proposed:

Mrs. Schwartz: Are you just looking for the space? Are you looking for Eddie **to have those as options for kids to choose**?

Mr. Reilly: No, **I think just having those as options I think is a good idea.** I think just to improve the curriculum and add more science and math into it. I think if you're looking to go that route, I think just going into any Science Wizards book for over the past few years and taking their building events because the engineering in there is unreal.

Mr. Reilly thus confirmed Mrs. Schwartz's provisional proposal of a new idea (Science Wizards challenges would be allowed in the Tech12 class), reconnected this new practice with "math" and "science", added an assertion that it will "improve the curriculum," and introduced a new actor that he believes should be present in Tech21: "any Science Wizards book". At this point, he has made moves involving language ("math," "science," and "engineering"); organizational rules (which activities will be sanctioned in Tech21); and support from powerful actors (the assistant principal) for a change in routine (his own daily schedule). He then related another story:

Mr. Reilly: Our kids, they went to the Eagle Lake library and they lasercutted all of their pieces so they could mass-produce their towers. That was an awesome thing, but they also spent weeks and months engineering these different prototypes of the bridges, which was awesome. I think that just having that incorporated into the curriculum would be awesome for the students and it would be more math and engineering and science based. Then I just think I just wanted to get involved more into the program just to, uh, help Eddie out, or incorporate more science into it, or just to figure out what is everything that can happen in here.

Notably, Mr. Reilly's story about the library was not about disciplinary math and science, but about precisely the kind of iterative design work that already occurred in the STEAM Lab. Mr. Reilly then reiterated his proposal for a change in the organizational routine, and added a new possible rationale: "to, uh, help Eddie out" before retreating to his earlier position to "incorporate more science into it."

Mrs. Schwartz then turned to face Mr. Jacobson.

Mrs. Schwartz: What are your thoughts on all of this?

Mr. Jacobson: I think it's cool. **I'd love to do a combination** because we were talking just about ideas and just to piggy back on all the Science Wizards that's … anytime I talk to a kid it was the same thing. [Kids say] **these [challenges in the STEAM Lab] are right along the lines of what they're doing [in Science Wizards].** Maybe even at a little bit, I don't want to say [air quotes] "higher level," but I feel like if you're in Science Wizards you want to do these [STEAM Lab challenges] a little bit more so.

Mr. Jacobson made a counteroffer: "to do a combination." He declined to reiterate Mr. Reilly's framing language of "math" and "science," instead asserting that there was alignment between the available STEAM Lab challenges and the Science Wizards challenges. He re-labels the Science Wizards activity Mr. Reilly proposes as "higher level" (as he had earlier called them "a little bit harder") but continuous with the STEAM Lab options.

Mr. Jacobson then continued, proposing a series of changes that could form the basis of a compromise:

Mr. Jacobson: I think that there's definitely more than enough room to collaborate and get things going. I don't know if it's starts in ... I think what we have to do is plan out how we see it flowing. Do we see **adding challenges into Tech21**? Do we see that maybe this could become like **a spinoff elective class**, or is this something **a part of the core class**, or do we **rotate all the science classes through here** and say pick a ... There's a lot of different ways that could go.

Mrs. Schwartz: I would love to see that. That's the level of integration I want to see. I want all of the science teachers to see this as a space that they can partner with Eddie and get things done that need to get done.

Mr. Reilly: Absolutely. I think **starting small**, like starting with this is a step in that direction because I don't think the science teachers and I know they don't know, because I don't know either, what we can actually do in here and what all the equipment available in here is. I think if I'm in here and I'm able to do these things, if it's flex twice a week or whatever, I can incorporate the science department more into it.

Mrs. Schwartz expressed general support for "integration" but did not actively take up any of the four changes Mr. Jacobson proposed. The changes varied dramatically, from expanding the number of challenges available in Tech21 all the way to creating a new elective class or changing the routines of core science instruction.

Mr. Reilly then makes a seemingly innocuous, conciliatory suggestion: "starting small." This has the dual effect of framing his upcoming proposal as something "small" and also establishes an expectation that, once implemented, it will lead to an expansion. Mr. Reilly then made a specific proposal: "flex twice a week." His slight deprecation of the proposal--"or whatever"—perhaps signaled a willingness to negotiate while using that proposal as a basis. As the meeting concluded, Mr. Reilly again reiterated his justification of "more science":

Mr. Reilly: I look at this space and I enjoy it. I want to learn about everything in here, and I want to be more involved and I was just thinking of ways that I could do that. That's why I e-mailed you guys. Because I was like, "I need to really start getting involved into this, because I'm doing myself a disserve by not being involved." I don't know how it would look, and I don't even ... Like I said, this is your program. I'm not trying to impede or anything. I just want to be involved and see what everything we can do and see how I can help and **get everything moving in the direction where there's more science being done**.

The next day, Jared, one of Mr. Reilly's star Science Wizards participants who was also a student in Tech21 (and whose drone-construction project is presented in chapter 3), overheard me and Mr. Jacobson discussing the previous day's meeting. Jared joined our conversation and I posed a question:

Peter: *If one of the reasons that Eagle Lake was thinking about including some Science Wizards stuff in here, was so that the STEAM Lab would have more math and science, what's your reaction to that?*

Jared: They [Science Wizards challenges] definitely bring more math and science like measuring and physics and stuff, but a lot of the math and science for Science Wizards is in the testing events and you're *not* going to bring a testing event to the STEAM Lab. You should *not* do that.

Peter: *Why not?*

Jared: Because no one would do it voluntarily. … I'd rather be making a drone than taking a test.

Jared here repositioned "math" and "science" as being more connected to the testing component, which he specifically ruled out as being inappropriate for the STEAM Lab on the grounds that students would never choose to do them. Mr. Reilly had emphasized the emergent, applied geometry of the car-building activity (relayed through his story about how "they started making angle sheets"). For Jared, however, the "math" of Science Wizards referred more to the difficult paper-and-pencil trigonometry test that accompanies the event.

In the end, despite the apparent consensus, no changes were made. Mr. Jacobson ascribed this to "our day to day teaching and environment, it's tough to get through everything we have to do, not enough time in the day" (Interview, February 26, 2019). Mrs. Schwartz spoke vaguely and in the passive voice: "nothing ever happened with that." Months later, I discussed this meeting with Mr. Jacobson.

Peter: *One possible interpretation is that Mr. Reilly was trying to get the STEAM Lab to be more about academic science and that in a sense you kind of held that back in favor of voice and choice, 21st century skills. Is that a fair interpretation?*

Mr. Jacobson: That's a fair interpretation. I really do want to keep it as a true exploratory course. These kids have a lot going on in their day. I find tremendous value in allowing the kids to be free and just learn by figuring stuff out. They need that.

A consequential change was in the offing, however. This change was not related to Mr. Reilly's overture with Science Wizards, but instead involved an opening up of the STEAM Lab to a different faculty member, this time with Mr. Jacobson's support. A few weeks later, Mrs. Schwartz established time at a summer in-service day for Mr. Jacobson to meet with the Industrial Design and Engineering teacher, Mr. Watley, about creating a new elective class. This meeting, which built on previous conversations between Mr. Watley and Mr. Jacobson, led to a series of conversations between the two teachers about creating a new elective class. The new class would preserve the choice-based activity structure of Tech21 and its emphasis on design and prototyping, but would "add the next step of fabrication or production" using the facilities of IDE (Interview with Mr. Jacobson, February 19, 2019).

Discussion: Negotiations and Compromises, Past and Present

All social order is "negotiated order" (Strauss, 1978). The process of negotiation is central to organizational and institutional change (Nadai & Maeder, 2008; Hall & Spencer-Hall, 1982). Wenger (1998) notes a double meaning in the word *negotiation*: people negotiate with each other to obtain agreement, but they also "negotiate" difficult terrain. The 2010's were a time of uncertainty at Eagle Lake, and the professional staff's negotiations were complicated and fraught with tension over the meaning and practice implications of "catchwords" (Dewey, 1938) such as "STEAM" and "voice and choice" and over access to limited resources such as time in the STEAM Lab. During periods of uncertainty and disagreement, actors seek to shape new courses of action, leading to negotiations: visible attempts by organizational actors to influence an ongoing contested social phenomenon according to their own interests and goals (Strauss, 1978). In this section, I discuss negotiations at Eagle Lake at both a "micro" timescale of moment-to-moment interaction and at a "macro" timescale of historical change.

Negotiation in interaction

In the contest for time and space in the STEAM Lab, Mr. Jacobson carefully negotiated the tense conversation with Mr. Reilly—strategically working to locate common ground through language (e.g., accepting Mr. Reilly's bid to focus on "that math and science lens") but shifting also to counterproposals such as a separate elective class that would preserve the choice-based model he had established in Tech21. Negotiations change cultural patterns by bringing emerging discourses forward into everyday life and generating new social facts (Nadai & Maeder, 2008). With his invocation of "design thinking" and "21st century skills," Mr. Jacobson sought to advance discourses connected to the humanistic logic and more firmly establish the Tech21 class within Eagle Lake's organizational routines. Power structures within organizations and existing lines of communication shape negotiation contexts. Mr. Reilly had called the meeting and invited the administrator Mrs. Schwartz, directing the bulk of his speech and physical orientation toward her.

Ultimately, Mrs. Schwartz possessed the power in the room and could have continued to exercise the institutional entrepreneurship that she had demonstrated in originally securing time and space for Tech21 to move the class in Mr. Reilly's direction. Had Mrs. Schwartz been so inclined, she had the option of, for example, scheduling a follow-up meeting with the two educators to make sure that Science Wizards challenges and its associated tests entered the STEAM Lab as Mr. Reilly had proposed. Instead, through her inaction she indirectly preserved the interests of students like Jared (who told a researcher "you should *not*" bring the Science Wizards tests into the STEAM Lab) by seeing to it that "nothing ever happened" with Mr. Reilly's proposal and instead laying the organizational groundwork for an alternative move. The meeting she did set up was between Mr. Jacobson and the IDE teacher, who began to discuss—negotiate—a new class that would further embed Mr. Jacobson's choice-based structure within Eagle Lake's routines.

Layers of compromise and the stabilization of Tech21

> Reuse with transformation of structures made publicly available through the actions of earlier actors leads to the progressive accumulation, with locally relevant modification, of structure inherited from predecessors, a process that sits at the heart of human action.
>
> Goodwin, 2018: 23

Over time, the compromises achieved through negotiations become part of the structure of everyday practice. The new structure then becomes the basis of future negotiations. Dr. Karlssen had brought to Eagle Lake an experienced administrator's sense of the need for inclusive decision-making, spending months in conversations with various stakeholders throughout the district. From this process, she presented the Board with a memorandum proposing, among other priorities, "STEAM" initiatives that, in her account, represented a general agreement within the community. At this point within the district's professional discourse, "STEAM" and its proposed operationalization through initiatives such as the STEAM Lab carried the essentialist logic; Board memoranda referred to "content and skills" of "science, technology, engineering, arts, and mathematics." Mindful that the "quants" on the Board sought scientific measurement and that "STEAM" might be difficult to measure, Dr. Karlssen and Mrs. Schwartz offered up the BrightBytes survey analytics tool to pair with the STEAM initiatives. This first compromise reiterated the district's well-established and broadly accepted scientific essentialist logic. Within this compromise, however, could be found the seeds of what would become a consequential change. The Board approved the STEAM Lab, leaving the implementation details to the administration. Dr. Karlssen had personally recruited a technology director, Mrs. Schwartz, who in turn selected Mr. Jacobson over other candidates for the Tech21 job. Mrs. Schwartz and Mr. Jacobson then worked as institutional entrepreneurs to use the authorized funding to advance the humanistic logic in Tech21 by designing a class routine that gave students freedom to choose their activity. At this point, Tech21 had been provisionally and tentatively established inside Eagle Lake using scientific essentialist logic—math, science, and engineering "content and skills" measured with the BrightBytes survey instrument—but its implementation was based on humanistic principles of student freedom.

The pendulum would swing back somewhat, however, in a second compromise. Once the Tech21 class had been installed for the 2015-16 school year, Mrs. Schwartz came to believe that it had insufficient structure. She searched out and brought in a new actor, FUSE Studio (Stevens et al., 2016), which she valued for its structured, progressively more complex challenges and well-organized video tutorials. This represented a new balance between the free-choice model that Mr. Jacobson had implemented and a more expert-directed model that the FUSE Studio represented.[17] Where Tech21 had become stabilized in the administration/Board dialogue through a compromise between scientific and essentialist logics (the "content and skills" of STEAM balanced with the BrightBytes analytics), it became stabilized within the teacher/administrator relationship by balancing humanistic and essentialist logics (Mr. Jacobson's "voice and choice" model balanced with the structured, expert-designed challenges of FUSE that Mrs. Schwartz had acquired).

A third compromise was present in the STEAM Lab. Implicit and unexamined by participants, embedded into Eagle Lake's routines, this compromise had roots that echoed back into Eagle Lake's history and had evolved over a long timescale. As described in Chapter 1, Eagle Lake's history during the McHenry era had been contentious. Parents reported uncomfortable confrontations in McHenry's office, and Board minutes document concerns over McHenry's methods and his defensive reactions to criticism (Talcott, 1962; Schumann, 1970). McHenry's original design for Eagle Lake in part sought to placate parents anxious about the

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[17] This was ironic, because all other implementations of FUSE had been interpreted by stakeholders as a move toward more freedom, not less. At Eagle Lake, the FUSE structure of progressively increasing challenge complexity represented a shift toward more expert direction than had previously been present.

"fads and frills" of the social and creative activities (Talcott, 1962) by offering a strong essentialist program. McHenry saw his approach, with the morning dedicated to common essentials and the afternoon to social and creative activities, as a carefully negotiated middle ground, "a very workable way to combine the best of society-centered education and the best of child-centered education and yet avoid the excesses of each" (Talcott, 1962). He thus executed a compromise between essentialist and humanistic logics by dividing time during the school day. With McHenry's dismissal in 1943 and the dismantling of the ambitious "social and creative" activities program amidst a national move away from humanistic education in the 1950's, Eagle Lake came to resemble other area schools, with a program of instruction in core disciplinary subjects combined with methods of scientific assessment to assess student learning in those subjects, and a substantially reduced presence of social and creative activities. Traces of McHenry's humanistic prescriptions extended into modern times, mainly though the "experiential learning" of the Pioneer Room and Civil War re-enactment activities. For the most part, social and creative activities were experienced by students outside of school, in camps and afterschool programs and at home, rather than within the school day (Interviews, 2017).

McHenry's focus on scientific measurement, in contrast, was continually re-iterated by his successors, with goal cards evolving into standards-based report cards and high-stakes tests. The remaining social and creative activities were significantly diminished in their time and resource allocation, down to one "elective" class, and Eagle Lake's focus on scientific measurement had made an important incursion: these activities were now rigorously "documented" and graded. Although McHenry had been dissatisfied with the lack of objective methods to measure social and creative activities (Talcott, 1962), these activities had nevertheless remained *ungraded* during his time. Student progress in the common essentials was carefully assessed through progress on detailed goal cards, but there was no equivalent assessment of social and creative activities. With the phasing out of McHenry's methods, Eagle Lake came to implement a practice of letter-grading its electives, just as other classes were graded. By the time Tech21 was established, participants accepted that the Tech21 class would be graded just as the traditional school subjects were graded.

Another compromise had come to be taken for granted, then—this one not negotiated but rather accepted as a given—involving a balance between the scientific and humanistic logics. Social and creative activities were still present, but would be *graded*. Accordingly, as will be discussed in Chapter 4, Mr. Jacobson developed a letter-grading rubric that judged students based on the extent of their participation in class, the production of weekly reflections, and a final portfolio, and he began using the ClassDojo tool to mark students down for certain actions. In the new compromise, a reduced program of social and creative activities was allowed into Eagle Lake, provided that a mechanism of assessment and accountability would be attached to it. Chapter 4 will show the consequences of this new compromise for one student.

Summary of Chapter 2

In this chapter, I examined the organizational and institutional environment in which a structured-choice learning environment, the Tech21 class in the STEAM Lab at Eagle Lake Middle School, emerged and appeared to stabilize. I established a conceptual framework using institutional logic (Thornton, Ocasio, & Lounsbury, 2012; Friedland & Alford, 1991) perspectives. I characterized the historical perspectives of K-12 instruction sketched in Chapter 1 as *logics* and extended this construct by emphasizing *accountabilities* (Strauss, 1985) within logics. I described the relative prominence of the various logics within accounts given by the professional staff about Eagle Lake's modern-day practices. I showed that the STEAM Lab was originally presented to the Board using scientific essentialist language, but that Mr. Jacobson and Mrs. Schwartz had shifted to humanistic justifications as the class ultimately became dedicated to student freedom and interest. I then used microethnographic data to explore the ways in which these logics were contested, analyzing a meeting in which the Tech21 teacher, the science department chair, and the district's technology director debated a proposed change to the STEAM Lab. Using this technique, I showed how the logics were spoken for and contested in moment-to-moment interaction. Finally, I suggested that the structured-choice learning environment became stabilized in a process of what Strauss (1978) calls a "negotiated order," as Eagle Lake established a compromise among the logics of classroom instruction.

CHAPTER 3

Learning in the STEAM Lab

Abstract

In this chapter, I report and analyze the student experience in a learning context designed on humanistic principles: Mr. Jacobson's Tech21 class in Eagle Lake's STEAM Lab. Drawing on 6 months of ethnographic and interview data in a STEAM Lab at a suburban middle school, I document the emergence of significant fluency on a range of digital and physical tools, as students created complex architectural designs, 3D printed original objects, built light-powered cars, and worked through diverse design and technology challenges. I also document consequential changes in students' social participation and identity. In an environment where students had freedom to choose their activity and received no direct instruction, how did this learning occur? I make a series of assertions about learning processes in this structured-choice environment, forming a process model I call *constructive interaction*, and consider the implications of the constructive interaction model as a resource for the design of learning environments. I then present a set of ethnographic cases that exemplify phenomena described in prior literature.

Introduction

How do students learn when they get to decide what to work on? This chapter investigates the student experience in the STEAM Lab at Eagle Lake Middle School, a *structured-choice learning environment* designed on the principles of student freedom, interest, and personal development. As defined here, a structured-choice learning environment provides diverse challenging materials available for the free use of students, together with instructional resources (such as texts and videos) that may be readily consulted. Research on such environments has documented productive activity, interest and skill development, and personal growth, as well as the emergence of a collaborative learning culture (Ramey & Stevens, 2018; Stevens et al., 2016; Stevens et al., 2018; Ramey, 2017; Penney, 2016). In the data presented in this chapter, I will show that students in the STEAM Lab developed complex design and technology skills, solved difficult technical problems, discovered new interests and capabilities, and formed new social connections. As a conceptual framework for the chapter, I will review the work of scholars who have conceptualized these achievements as "learning" and draw on their ideas in responding to the research question *How do young people learn in a school-based structured-choice learning environment?* I present a general process account that describes students' *projects* (Kilpatrick, 1918) and *lines of practice* (Azevedo, 2011, 2013) in the STEAM Lab. This process account, which I call *constructive interaction*, consists of a series of assertions grounded in and progressively refined from a systematic analysis of field notes and video content logs (Corbin & Strauss, 2008). Next, I present a series of student learning stories, or ethnographic *cases* (Ragin & Becker, 1992), that exemplify the constructive interaction model and, in one case, reflect phenomena documented in previous educational and learning sciences literature. In both the process description and the ethnographic cases, I seek to provide an *experience-near* (Geertz, 1974, 1976) account of student activity, with detailed and extended attention to students' own reactions, perceptions, and interpretations of the work and the overall environment.

Theory & Literature

What "counts" as learning

Research in the learning sciences has produced a range of meanings and associations around the term "learning." In this section, I outline 6 ways that learning has been conceptualized within educational research. These include learning as *internal cognitive reorganization* (Piaget, 1952; Bruner, 1960; di Sessa, 1988; di Sessa & Sherin, 1998), *knowledge in practice* (Stevens et al., 2008; Hall & Stevens, 2016)*, increasingly consequential participation in social practices* (Lave & Wenger, 1991; Rogoff, 2003, 2014; Rogoff et al., 2003), *change in identity* (Holland, 2001), *successful navigation through institutional requirements* (Stevens et al., 2008), and finally as *personal development* (National Research Council, 2013).

Internal cognitive reorganization. In the cognitive constructivist account, people learn as they perceive and act on novel phenomena, connecting new experiences with prior knowledge; this experience leads to the development of more normatively organized, nuanced, and increasingly complex mental structures and to conceptual change (Piaget, 1952; Bruner, 1960; diSessa, 1988; diSessa & Sherin, 1998). Researchers working in this tradition, which is foundational to the learning sciences, have proposed mental entities or structures (Bruner, 1960)—including schemas (Bartlett, 1932/1995; Piaget, 1952; Rumelhart, 1984), scripts (Schank & Abelson, 1977), and concepts (di Sessa & Sherin, 1998)—and sought to describe the mechanisms of their development and change.

Knowledge in practice. Hall & Stevens (2016) argue that the internal cognitive lens is best suited for analyzing learning in the absence of outwardly observable activity such as the use of an external representation, as when people can be seen calculating a math problem "in their head" without using devices or symbols. In contrast to the cognitive constructivist stance, views of learning as physical, situated, embodied, distributed, and interactional (Lave, 1988; Hutchins, 1995; Stevens, 2012; Ryle, 1949) have motivated empirical investigations of the development of knowledge in cultural practice (Cole, 1996; Lave & Wenger, 1991; Rose, 2004; Scribner & Tobach, 1997; Saxe, 2015; Stevens et al., 2008). The knowledge in practice perspective investigates contexts in which people come together to achieve a goal, "accountably to their own satisfaction and to the organizational requirements of their work" (Hall & Stevens, 2016: 73). A core commitment of this line of research is that what "counts" as learning is not the acquisition of a general, universally accepted body of knowledge but the ability to execute a specific, local production that is accountable to the criteria of the participants in an interaction (Stevens, 2010). This perspective thus recognizes displays of academic expertise, such as a correct answer to a trigonometry test question, as analytically symmetrical to demonstrations of skilled practice, such as using a keyboard shortcut in a software application.

Social participation. Lave (1988) argued that "what we call cognition is in fact a complex social phenomenon" (1). Scholars have long contrasted school-based instructional activity with the forms of social organization that occur as people learn outside of school, where new capacities emerge through a process of observation and increasingly consequential participation in the everyday practices of the family, community, and workplace (Lave & Wenger, 1991; Dewey, 1897; Becker, 1972; Lave, 1988, 2011; Rogoff, 2003, 2014). Lave & Wenger (1991) described a phenomenon of *legitimate peripheral participation*, in which people begin participation in communal activity by performing nonessential tasks, then gradually take on work of progressively increasing importance. Learning in this sense is socially distributed; what "counts" is that people become more skillful over time at achieving goals within a collective.

Changes in identity. Holland et al. (2001) defined *identity* as "the imaginings of self in worlds of action" where "people create new activities, new worlds, and new ways of being" (5). Beach (1999) pointed to "consequential transitions" in identity as people experience "becoming someone or something new" (102). Scholars increasingly recognize identity development as a central dimension in analyzing learning (e.g., Wortham, 2006; Moje & Luke, 2009; Nasir & Hand, 2008). Some researchers have investigated the development of identity within the context of an academic discipline, such as mathematics (e.g., Boaler & Greeno, 2000; Cobb, Gresalfi & Hodge, 2009), exploring the ways in which students understand their capacities in relation to a school subject. Others have investigated the development of identity in out-of-school contexts (e.g., Barron, 2006; Nasir, 2002). Holland et al.'s (2001) association of identity with the "self" has a long history, as described in Chapter 1. In that chapter, I showed that early theorists suggested that learners sought to develop their "truest, strongest, deepest" selves (De Garmo, 1911: 17; Dewey, 1913; Holmes, 1912). Taken together, these historical and present-day theories point to a view of learning as the individual's discovery of a new possible identity and the development of agentive skill to achieve that new identity. Identity is, to be sure, a "double sided" phenomenon (Stevens et al., 2008). Holland et al. (2001) note that people must also be *recognized* as having a certain identity, e.g., as a "chef" or as a student who is "good at math." A person who identifies with a certain practice, in other words, must also be seen by others—

whether people such as friends, family members, teachers, and colleagues or organizations such as schools and companies—as a legitimate participant in that practice (Stevens et al., 2008).

Navigation. In formal learning environments, learning is often conceived as the completion of institutional requirements. In common understanding, a person who is "learning" or "doing well in school" is receiving high grades and moving through the school's organized progression. The "obligatory passage points" (Latour, 1987) of educational institutions consist of milestones such as being admitted as a student, completing a required course, and graduating (Stevens et al., 2008). Within a particular course, such obligatory passage points might include turning in certain assignments or passing certain tests. Successful navigation of these milestones requires the production of disciplinary knowledge, but also may involve strategic "tricks of the trade" such as knowing when to take certain courses, which teachers are easier or harder, how much studying is required to achieve a certain grade, when late work can be accepted, and how to negotiate with an instructor (Stevens et al., 2008). "Doing well in school," in other words, is itself a skill, which might be better described as "doing school well." This navigational skill can determine success within an academic career.

Personal development. As described in Chapter 1, other definitions of learning include skills associated with resilience, creativity, teamwork, leadership, self-direction, innovative adaptation, and problem-solving, sometimes called 21st century skills (National Research Council, 2013), character (Heckman & Kautz, 2014), non-cognitive skills (Levin, 2013), or personal qualities (Duckworth & Yeager, 2015). Popular writing on education (e.g., Wagner & Dintersmith, 2015) often takes this perspective on learning, calling for environments that support personal development.

Research Context

I selected "Eagle Lake Middle School" as a research site for three reasons. First, district leaders had established the "Tech21" class in a newly-remodeled STEAM Lab, providing the "extensive and varied material infrastructure" (Azevedo, 2013), "environment rich in interesting material" (PEA, 1919), and choice-based activity structure that are central what I have defined as a structured-choice learning environment. The district's director of technology had acquired FUSE Studio (Stevens et al., 2016), seeking to add FUSE to its already-diverse collection of STEAM activities in Tech21, and the Tech21 teacher participated in FUSE's training and professional development program. Second, Eagle Lake was a highly facilitative research context: administrators were eager to participate in this study, made themselves available for interviews, and allowed me to observe the Tech21 class at length. Third, as described in Chapter 1, Eagle Lake has a long and well-researched history of educational innovations dating back nearly a century, providing a historical context and literature to draw on in analyzing the district's modern-day practices.

I initiated the research with a series of hour-long interviews with the school and district leadership teams in November 2016. I then began observations in the STEAM Lab. I attended 3 Tech21 classes per day on 35 observation days between November 2016 and June 2017, and conducted follow-up interviews with 3 students in November 2017. I conducted a 2nd round of interviews with administrators in the fall of 2017, this time exploring issues related to the ethnographic cases I had uncovered. On two occasions, I also observed other classes in the district, including a 4th-grade math class and an 8th-grade science class attended by several students who I had observed in Tech21. Finally, I reviewed district memoranda and policy documents, such as reports and proposals given by the administration to the school board.

Research Design

My research design originated with a contradictory premise. Given the freedom of choice and the diversity of materials, tools, and technologies, I expected that each student's "interest pathway" (Ramey & Stevens, 2018) through Tech21 would be different. At the same time, I believed it would be possible to produce a generalized, unified process account of learning activity in Tech21. This chapter, then, presents and analyzes data in two different ways. First, I produce a *data narrative* (Azevedo, 2013), a "stitching together of various moments of practice taken from across the full ethnographic period that therefore presents a coherent whole of individual and community practices" (472). From this narrative, I propose a series of *assertions* (Stake, 2010: 192; Erickson, 2012) that described recurring phenomena that I observed, illustrated with examples from the data. Working within the grounded theory tradition, my goal was to integrate these assertions into a *paradigm model*, "an organizing scheme that connects subcategories of data to a central idea, or phenomenon" (Kendall, 1999: 747), that describes learning under the conditions of structured choice found in the STEAM Lab. This paradigm model, however, cannot account for the radically heterogeneous character of learning. Each student's experience in the STEAM Lab was different. Accordingly, after presenting the process framework, I present a set of ethnographic "cases" (Ragin & Becker, 1992) that examine the student experience more closely and, in one case, make an explicit connection with findings from prior literature.

Units of Analysis

The units of analysis in this chapter are the *project* (Kilpatrick, 1918) and, more broadly, the *line of practice* (Azevedo, 2011). Adapting Azevedo's (2011: 147) definition, I consider a line of practice as a pattern of willing and active participation in an activity that is sustained over time. Both projects and lines of practice, as defined here, involve freely chosen, "wholehearted purposeful activity" (Kilpatrick, 1918: 6). The difference is that a line of practice (e.g., computer-assisted jewelry design) might or might not continue after a particular project (e.g., a first attempt at designing and 3D printing a bracelet) has been completed. Lines of practice and projects are the basis for both the general process account and the specific cases that follow. My analysis begins with a student's (or group's) expression of interest in an activity and follows it through to the point where the student or group has completed a particular work to their satisfaction (a project) and possibly continues on (a line of practice).

In presenting and analyzing projects and lines of practice, I attend closely to activity as integrally bound up with and connected to its social and material environment, that is, consisting of people and things in interaction. Lave (1988) called for the study of "persons in context"; Kilpatrick argued that "the true unit of study" is "the organism-in-active-interaction-with-the-environment" (1951; quoted in Beyer, 1997); and Dewey (1934) wrote:

> The first great consideration is that life goes on in an environment, not merely in it, but because of it, through interaction with it … the career and destiny of a living being are bound up with its interchanges with its environment, not externally but in the most intimate way" (13).

Accordingly, attention to the processes of individual learning in the STEAM Lab necessarily includes attention not just to people but also the things around them. All of the student activity in the STEAM Lab involved "hands-on" work or "making" (e.g., Pinkard et al., 2017; Peppler, Halverson & Kafai, 2016; Eisenberg, 2003; Peppler, 2013), either of concrete or digital artifacts. Students worked with architectural and interior design programs, 3D printers, explainer and tutorial videos, textiles, circuits, timers, calipers, motors, music and video production applications, and countless other devices and tools. Students routinely drew on each other as critical resources of expertise and assistance, forming task groups involving elaborate divisions of labor (Stevens et al., 2016; Stevens, 2000b). Problem-solving and creative work was distributed across the social and material environment (Hutchins, 1995), and the diverse resources students assembled are integral to my accounts of their projects and lines of practice.

Data Collection Procedures

This chapter and Chapter 4 are situated within the participant observer tradition (Emerson, Fretz & Shaw, 2001; Delamont, 2004). My early site visits involved spending time informally with students as they worked and building rapport with them. I took field notes on a MacBook Pro computer. Students were curious about my notes and I would show them what I was writing. Gradually, they became accustomed to my presence and stopped expressing curiosity. As the forms providing parental and student consent for research participation began to come in, I started recording video and audio using an iPhone 7.

With a few exceptions, I did not conduct formal, structured interviews outside the context of activity. Instead, my questions to students were presented casually, during their work and in transitions between projects. Students would overhear my questions directed at others and chime in with their own answers, agreements, and embellishments. I relied on open-ended, nonspecific questions designed to produce free associations and projective answers. For example, I would walk up to a student or a group of students and ask, “What’s up over here?”, “What’s going on today?”, or “Hey, can you tell me about this?” After I observed what I interpreted as an important interaction (such as Mr. Jacobson giving suggestions to a group) I would ask, “What just happened?” or “What was that all about?” When students worked on teacher-required activities (such as a weekly reflection), I often asked students why they were doing them.

At the same time, I had a few recurring questions that I asked many students:

- “How does Tech21 compare with your experience in the rest of school?”

- "What advice would you give to a student just starting out in Tech21?"
- "What did you learn doing this?"

These questions were derived from a previously tested interview guide used for FUSE Studios and developed collaboratively by the research group investigating FUSE at other sites. A common activity in Tech21 was the construction of digital structures or environments using the architectural design software SketchUp or the block-based construction tool Minecraft EDU, and accordingly I frequently asked students to give me narrated "tours" of these often intricately designed spaces and communities (Hanington & Martin, 2012).

Analytic Procedures

After data collection, working with a research assistant, I edited 403 video clips into 31 "collections," sorted by either individual student (or, in some cases, by pair or group) and then compiled chronologically. The resulting collections followed a student or group through their projects during the quarter.[18]

General process account: coding method. I used the method of grounded theory as I analyzed the collections to produce the general process account (Strauss & Corbin, 1994). The phenomena that I attended to derived from the research question *how did students learn under conditions of freedom and choice?* I created a content log (Jordan & Henderson, 1995) for each collection, printed all of the content logs, and also printed my field notes. I watched the videos and read through all of this material once to get a sense of it as a whole, then watched and read through additional times, writing initial, provisional codes in the margins that were progressively

[18] Because of the fluidity of the groups, some clips appeared in multiple collections: student A and student B might have come together for a week to collaborate on project X, then returned to their independent work. The clip of project X would then appear in the collection for both student A and student B.

refined over the course of the analysis. During this open coding process, I first relied on in vivo coding (King, 2008) that captured participants' direct language, rather than summarizing or characterizing their actions. After the in vivo codes were identified, I then developed an extensive set of low-inference descriptive codes.

I now present examples of this coding procedure. In this excerpt, Franklin explains why he had chosen to use architectural design software to create a tower in a particular concave shape:

Franklin:	I've always liked circle stuff. Because basically everything we see [around us] is basically square, boxy, and I think a little boring. Circular just has a little twist in it.	**"always"** **making it not boring**
	I was looking for something that looked appealing to me, not something really boring, but something hard. I thought this would be good. That curve, it's unusual. … I'm trying to recreate it … but I don't know how to do that [in SketchUp] [to create] a perfect curve. So I'm just letting it have these little steps, like a pyramid.	**personal taste** **choosing hard things** **making it unusual** **trying to recreate** **not knowing how** **compromising** **model from memory**

The most common in vivo code involved *figuring out*, as seen in this passage from Maxine's comments during her construction of a cardboard chair.

Peter:	*How's the chair coming?*	
Maxine:	Pretty well. I just need the hot glue gun that Mr. Jacobson has to order. But I'm figuring it out. My plan is to make … I already have a lot of these [triangles] made, so I'm actually going to make 3 of these on each side, so it's thicker and stronger, and then have these in the middle … it's going to be more like a cardboard stool, but hopefully it will work.	**obtaining materials** **figuring it out** **planning before making** **production specifications** **models from memory**

I also coded my field notes, as in this example of a group working on an architectural design software challenge:

Three girls are focused intently on their laptops, their shoulders low. They are doing SketchUp. "Four by eight!" "How do I get back in the house? I am SOOOO confused!!" Blond girl solves the problem. "There we go." Not clear if she is talking to herself or for the benefit of others. Others begin narrating their own work like blond girl.

SketchUp
being confused
solving problems
thinking out loud

In addition, I coded some stills from the video and photographs. Given that one of my units of analysis was the *project,* I accordingly sampled images in which there was a particular concentration of work to start or advance a project. This included identifying something to work on, finding people to work with, actively working to design or create something, or concluding the project by, e.g., writing a "reflection" in accordance with Mr. Jacobson's direction.

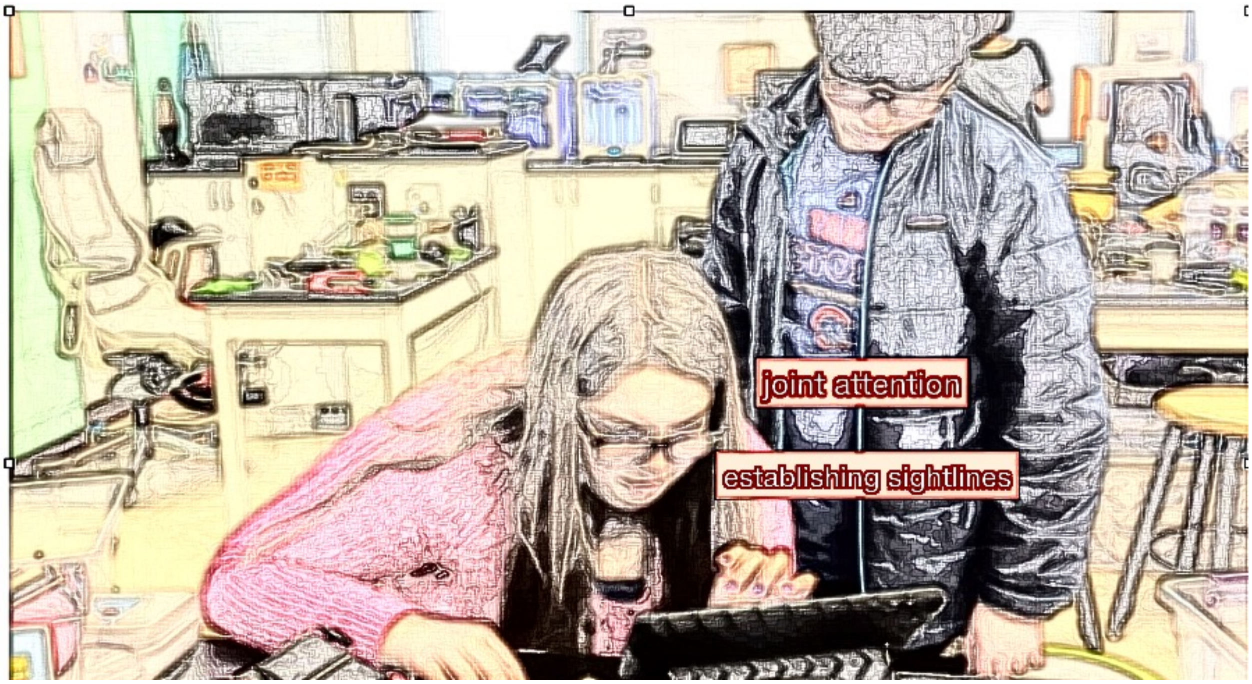

Figure 4. Coding from video stills

This process of coding the 31 collections, images and field notes produced 189 codes. After generating this set of open codes, I began the process of axial coding, "a set of procedures whereby data are put back together in new ways after open coding, by making connections between categories" (Strauss and Corbin, 1990: 96). The first step in this re-assembly involved organizing them into a general chronology that described how students proceeded through steps as they tried to achieve their goals. I sketched informal connections and groupings among the codes. I then entered the content logs, field notes, and codes into the qualitative data analysis software AtlasTI. Qualitative data analysis software (MacMillan & Koenig, 2004) enables retrieval and display of all instances of a code across the data corpus. For example, I was able to retrieve each time a student spoke of "figuring out" and notice the variations in the ways in which students used the term. This process enabled me to analyze the properties and dimensions of phenomena (Corbin & Strauss, 2008). Analysis of these codes allowed for progressively more refined scrutiny and organization of conceptual categories (Charmaz, 1990). Finally, I organized the codes into a rough sequence and wrote this sequence in narrative form, following a stylistic model from Azevedo (2013). Collectively, this data formed the basis of 7 specific empirical claims, which I support and analyze using examples from the data narratives.

Ethnographic cases. During data collection and through the analysis phase, my attention was drawn to certain events and student experiences. This "noticing" was shaped by prior theoretical and empirical literature, and specifically by research on FUSE Studios (Ramey, 2017; Hilppö et al., 2016; Ramey & Stevens, 2018; Stevens et al., 2016; Stevens et al., 2018; Penney, 2016). I chose certain cases for analysis here as exemplars through which to apply and in some cases extend the concepts presented thus far in this study and for their connection with prior literature. Jenna's interest in designing and printing a puzzle necklace to memorialize her friendships recalled De Garmo's (1911) and Dewey's (1913) material and social sources of interest. Cecilia's shift from being "this shy person" who did not feel comfortable sharing her artwork to creating an Instagram for her art represented a consequential transition (Beach, 1999) in her developing identity as an artist. The story of Kyle and Ellen, students who successfully completed a complex technical challenge involving a light-powered car, recalled a compelling case of a student with a "learning disability" reported by McDermott (1996). The case of Kira, whose developing technical and creative skills led to respect from her peers and a powerful experience of personal transformation and growth, culminated in a difficult outcome for her and her teacher, and has resonance with Stevens' (2000a) study of a project-based learning environment. I present this case in detail in Chapter 4, where it serves to illustrate the institutional dilemmas and tensions described earlier.

Tech21 in the STEAM Lab

Overview

School leaders built the STEAM Lab at Eagle Lake in 2015, remodeling the school's old science lab (*see* Figure 5). A former technology coach in the district, Mr. Jacobson, was recruited to teach a new elective class, Tech21, scheduled for 35 minutes per class, 5 days a week. After an introductory week of "design thinking" lectures and activities, students in Tech21 were allowed to choose from 32 FUSE Studio "challenges" (Stevens et al., 2016) or from activities in the STEAM Lab, including Minecraft EDU, a rocket-design simulation called Kerbal Space Program (KSP), and devices they could program such as the Sphero robot. The FUSE challenges (added to the STEAM Lab in 2016 to bring increased structure to the program, as described in Chapter 2) included a range of creative tools such as the architectural design software SketchUp, the 3D modeling software TinkerCAD, the programmable robot Sparki, and a variety of kit-based, material assembly challenges such as a light-powered LEGO car. Students were permitted to work independently or in groups and, with occasional exceptions, given broad latitude to decide what to do from moment to moment. Students were encouraged but not required to use the FUSE challenges, and about one-third to two-thirds of the activity in the room took place in FUSE. The FUSE challenges related to architectural design and 3D modeling were the most popular. Of the non-FUSE activity, much of it took place in Minecraft, with students typically collaborating in Minecraft to build structures such as local sports stadiums, models of the town of Eagle Lake, and fantasy worlds.

I now turn to the findings from my observations and analysis. First, I describe a "typical day" in Tech21 to give the reader a grounding in the classroom context in which these projects took place. I then present the "data narrative," which represents an intermediate level of analysis, abstracting and summarizing recurring activity in Tech21 into a series of italicized descriptive codes. After the data narrative, I present the core of the analysis: 7 assertions that describe student work to advance their projects. Following the assertions, I discuss these assertions as a process model of learning in the STEAM Lab.

A Typical Day

Students would enter the STEAM Lab and go directly to their work, without awaiting direction or instruction from Mr. Jacobson. (A substitute teacher encountering the class for the first time and seeing the students start working independently remarked to me that she had not seen anything like that before.) On average, about a third of the students worked on individual projects, while the rest worked in groups of two to four. These groups usually, but not always, tracked existing social relationships—that is, students generally worked with their friends, but sometimes made new connections. The line between individual and group work was fluid, as described in earlier research on FUSE, with students who were doing individual projects frequently asking for help and feedback from others (Penney, 2016). Students using Minecraft typically worked on a structure or a collection of structures within a designated area on the class's server; one would work, for example, on a rooftop garden for an office building while another would design a cafeteria. The students would coordinate when needed, such as in deciding where a staircase would be placed to provide access to the rooftop garden from the cafeteria. Mr. Jacobson spent about one-third of the class walking around checking in with various groups, providing procedural advice (such as a recommendation that students plan and sketch before starting work) and making functional suggestions (such as encouraging students to make their designs more realistic or to think about the needs of users). These suggestions usually went unheeded, as students waited for Mr. Jacobson to move on to the next group and then returned to what they had been working on.

Figure 5. Digital and tangible activities in the STEAM Lab.

Left: A student works individually on the space-exploration software Kerbal Space Program.
Center: Students set up an obstacle course for a Sphero robotic ball.
Right: Students working jointly on a Minecraft project.

Many students worked together on a single project, but a common pattern was that students would work in parallel, each on their own project, while actively consulting with each other for help, advice, or feedback (*see* Figure 6) (see Penney, 2016). Students designing their "dream home" in SketchUp were working independently, since unlike Minecraft the software did not allow multiple students to work on the same structure from two different computers. However, students routinely positioned themselves close together so that each could easily look at the other's screen, and they continually showed their designs to one another. The physical design of the room (tables that made it easy to work next to one another) and the fact that each student had access to a mobile device (tablet or laptop) strongly facilitated this type of learning arrangement. Students moved fluidly among individual, joint, and parallel work, and moved back and forth among different groups, in a phenomenon previously documented by Penney (2016).

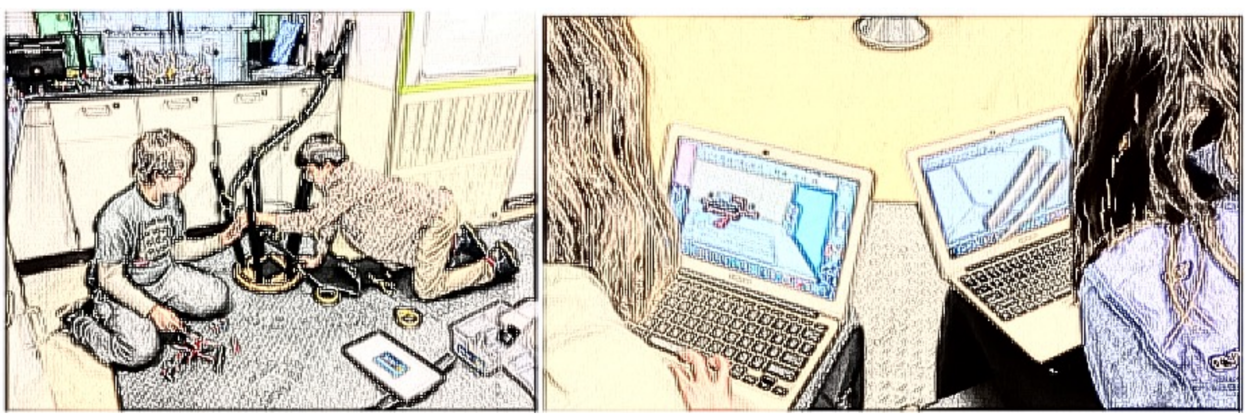

Figure 6. Joint and parallel work.

Left: In joint work, students build a coaster track for a marble.
Right: In parallel work, students each build their own "dream home", but actively consult with each other on design decisions.

Other students worked on physical challenges, assembling and operating mechanisms, devices, and structures from kits and from generic building materials available in the STEAM Lab. A pair of students might use the LEGO Mindstorms robot, programming it to advance until it encountered an obstacle, then to turn around. (This often led to unstructured and improvised experimentation, such as causing the robot to knock the obstacle over and drive through it.) Many students came into the STEAM Lab, with Mr. Jacobson's permission, on their lunch hour. Typically this work involved access to concrete materials and tools, such as a 3D-printing pen, that were only available in the lab and not on the devices that students carried.

The main problem Mr. Jacobson encountered during class time was not a lack of student engagement—students were mostly "on task," in his words—but rather destructive practices, particularly on the class Minecraft server. Students would complain to Mr. Jacobson about someone "griefing" or "trolling" them—damaging their Minecraft structures by, for example, flooding them or removing bricks. This destructive activity, which I discuss later in this chapter, was an exception to a more general collaborative culture or spirit of the class—documented in research on FUSE (e.g., Stevens et al., 2018, 2016)—in which students routinely stopped their own work to provide help and guidance to others upon request. During Tech21, the STEAM Lab thus had a moderate "buzz" that Mr. Jacobson said he liked, along with occasional sharp words as students worked through problems involving griefing and trolling.

Students in Tech21 were engaged in their work throughout the 35 minutes of class time. Multiple students remarked that time seemed to go faster during Tech21. One student asked Mr. Jacobson whether the period was itself shorter than the other periods during the school day (leading a friend to respond that it was not, it just felt that way). Mr. Jacobson had to exhort many students to leave when time was up, as they did not want to stop working on their projects.

Theorizing Structured-Choice Learning

In this section, I organize common codes into a narrative form to show a general sequence of activity in the STEAM Lab, synthesizing data from all of the field notes and video collections. I sought to write the codes as low-inference descriptions (such as *moving computers* or *taking a video*) and to incorporate participants' language where possible (such as *making it cool* or *figuring out*). In presenting the codes in this format, I draw on a "data narrative" style used by Azevedo (2013: 479-490) in his grounded-theoretical study of amateur astronomers. I use this technique as an intermediate level of analysis, a bridge between the overview presented above and the paradigm model that follows.

Data narrative

Students in Tech21 experienced the environment in the STEAM Lab in various ways before *starting a project* or *deciding what to do next*: through *seeing* (which sometimes led to the more attentive *watching*), *hearing* (which sometimes led to the more attentive *listening,* as to *suggestions from the teacher* or *suggestions from friends*), and *reading.* These experiences often led to *announcing a plan. Starting a project* included *obtaining materials* and *arranging materials* (often by *moving computers* or *setting up computer windows).* Student work involved *trying to replicate*, *finding models* from *pictures, videos,* or *memory,* and allocating *individual attention* or *joint attention.* This stage of the process involved continual expressions of *figuring out.* A common approach for *figuring out* was *finding models from others*, *examining mechanisms,* and *watching intently*, all of which required *establishing sightlines. Asking questions* was a common practice for figuring out and the process often included *gesturing to represent.* I observed frequent *sketching before making* or *planning before making*. *Functional goals* for artifacts and *practice goals* for skills served to provide objectives for activity. Students found or created *production specifications* and proposed *project goals*. *Design goals* included *making it interesting, making it cool, making it not boring,* and *making it different,* which sometimes led to the creation of *fantasy structures,* although a *teacher design suggestion* usually involved *making it more realistic.* Inability to achieve project or design goals sometimes led to *compromising.* Students frequently displayed *excitement,* especially after *accomplishing* or *getting it done.*

Students often experienced *failure,* which led to *troubleshooting*, *solving problems, giving up,* and *trying again.* Strategies for responding to *failure* included *watching videos, re-watching videos, reading instructions, re-reading instructions* and *asking for help.* Students often encountered *problems of scale,* which emerged frequently during the process of *trying to replicate* objects and processes. A recurring problem in the STEAM lab, however, was *destruction* of digital and physical objects, which students called *trolling* and *griefing*.

I listened for specific *terminology* used during student activity, which included mainly single occurrences of technical or academic terms such as *parabola, Jack and Jill bathroom, pitch, bevel, caliper, CNC machine, extruder, mod, open concept,* and *spoiler.* Students often did not know or could not remember appropriate reference terms and used *placeholder terms* such as *thingie* or relied on *invented technical terms* such as *velocity amplifier*. On occasion, *disciplinary knowledge* in mathematics, physics, history, or other academic subjects was invoked or alluded to.

After completing a step in the process or finishing production of an artifact, I observed students *documenting* their work by *taking a video* or *writing a reflection* in response to Mr. Jacobson's *class requirements.* This process of completing a step or finishing production sometimes involved *encouragement, asking for critique, giving critique,* or *receiving critique,* which were components of *being evaluated,* although *self-evaluation* also occurred. Class requirements included *reflections* and a *portfolio,* and Mr. Jacobson assigned a *grade,* including a *participation grade.* Many students expressed *concern about grades.* The teacher used *learning management systems* and *classroom management systems* that included *Google Classroom, ClassDojo,* and *ClassCraft.*

Students' activities and statements often reflected *prior experiences* including *experiences from home, experiences from other classes,* or *experiences from other programs* such as *STEM camps* or *clubs.* I observed significant *coming in during free time,* as when students elected to spend a lunch or a free period in the STEAM Lab, as well as *working outside of class,* when students worked on their Tech21 projects at home.

A process model of learning in the STEAM Lab

I now present a process model of student learning in the STEAM Lab, organized into a sequence of "assertions" (Stake, 2010; Erickson, 2012) that each cover a range of ethnographic observations and statements by students.

Assertion #1: When Students Noticed An Object Or Activity That Interested Them, They Took Steps To Explore It

Students in Tech21 had the opportunity to make moment-to-moment decisions about what to do. They walked around the room investigating various options, browsed the FUSE website watching preview videos that promoted various FUSE activities, searched the Internet for ideas, or simply were attentive to things happening around them that presented an opportunity to start doing something new. At some point, students noticed some particular object or activity and began to "focus" on it, in the sense of orienting to it physically, visually and auditorily. Gavin, a 7th grader, started the quarter by designing a model of the Eagle Lake town hall in Minecraft. Seated near Lawrence and Jonah, two higher-status 8th grade boys, Gavin overheard and saw them discussing their project, a complex of structures built in Minecraft's "creative mode" which they called the Minecraft Hill Community. Gavin stepped away from his computer, took a position over Lawrence's shoulder and began closely attending to his work (*see* Figure 7.)

Figure 7. Gavin notices and attends to the Minecraft Hill Community.

Gavin placed his body so as to create a sightline to Lawrence's work, watched as Lawrence constructed the "main hall" of the Hill Community, and listened to Lawrence and Jonah discuss possible enhancements for developing their structures. This moment of noticing and focusing represented the end of Gavin's Eagle Lake town hall project, the beginning of his Hill Community project, and a continuation of his line of practice as a Minecraft coder. Gavin's freedom to change his focus from the town hall to the Hill Community was a central point of difference between Tech21 and his experience in other classes at Eagle Lake. In Tech21, Gavin was permitted to redirect his time and attention from one project to another. Although Mr.

Jacobson encouraged students to continue their project work through to a concrete achievement, he did not insist that students finish what they started. Students' ability to choose what to focus on, as opposed to having their attention directed by a teacher, allowed this voluntary process of engagement to occur. This ability to choose was important to them and was expressed to me many times:

> In the rest of school, you're kind of given what you're supposed to do. Like, in math, it's like, "Today, we're learning about fractions!" Here, you just go in, and if you want to learn about something, you just *do* it. It's not where you're *told* to do something. And I like that. *Franklin*
>
> I think it's cool that you get to choose what you get to do. In other classes, even in art classes, you just have to do whatever the teacher tells you to do. *Gwen*
>
> I just like how you can pick what you want to do and there's a lot of different things to do. You can expect to do things you like. It's not like you get into guitar class and, like, you hate guitar and you have to do it the whole trimester. You get to choose what you like and work around that. *Hailey*

The question of what caused a student to notice and focus on one activity rather than another is difficult to investigate empirically: we can see *that* a student directed their attention toward something, but not *why*. Asked why they chose a certain activity, students commonly responded only that it "seemed interesting" or "looked fun." In Chapter 1, I presented Dewey and De Garmo's explanatory framework for the move toward a particular activity (i.e., why students would find something interesting), which centered on its perceived instrumentality to the material, social, or spiritual development of the individual (De Garmo, 1911; Dewey, 1913). The "material" dimension of the interest framework proposed by Dewey and De Garmo includes attention to shelter and housing, which enable the individual's survival. As the framework predicts, many students spent the entire trimester working in architectural design software designing bedrooms, houses, and neighborhoods; the Minecraft Hill Community included elaborately designed living spaces. The Dewey and De Garmo framework also proposes that people will be interested in decorations for the body, and indeed another substantial portion of activity involved the design and fabrication of bracelets, trinkets, and small decorative objects. 7th grader Kira initiated an extended line of practice as a 3D designer after identifying the TinkerCAD software as a tool she could use to make jewelry. The "social" aspect of the Dewey and De Garmo framework includes connections with and respect from peers. Gavin told me that he enjoyed coding, but he appeared drawn to an opportunity to form a social connection with higher-status boys, frequently underscoring to me and Mr. Jacobson that he was "part of" the older boys' group. Jenna, an 8th grader anxious and sad about her upcoming move out of the country, began using TinkerCAD as a way to create what she called a "friendship necklace," a piece of jewelry to give to each of her friends "so we could always be connected in some way." The "spiritual" aspect of the interest framework, which earlier in this chapter I connected to theories of identity, usually emerged late in a project (as will be shown in the case of Kira) but in cases where a student brought an outside identity into Tech21, this shaped the initial choice of a project. Later in this chapter I present the case of Cecilia, who was developing an emerging sense of herself as an artist and, accordingly, chose to learn a sketching app to advance this line of practice.

The early interest framework by De Garmo and Dewey does *not* provide a satisfactory account, however, for other choices students made about what to focus on. In the technology-rich environment of the STEAM Lab, students were often drawn to activities that produced what Papert (1980) called "powerful effects". For Ellen and Kyle, the fascination of a preview video in which a car was propelled forward with a flashlight appeared to catch their interest as a novel physical phenomenon and cause them to investigate further and take up the activity. Kira spent two class periods working on a Cubelets project, assembling interlocking blocks into a moving robot. Kerbal Space Program, which enables students to launch simulated rockets and satellites, formed the basis for many student projects. Each of these powerful effects attracted students' attention. A century earlier, without modern technology, such effects were more difficult to achieve, which perhaps explains these early scholars' inattention to the attention- and interest-generating effects of dramatic phenomena.[19]

The assertion that when students noticed something that interested them, they took steps to explore it is, to be sure, sufficiently general that it describes any agentive action. However, it makes visible certain dimensions along which this action might vary. For example, in the science class I observed, the noticing was directed by the science teacher, who directed students' attention to a screen on which she was displaying a solubility graph. The graph may or may not have interested students, and the steps they took to explore it (using it as a tool to respond to the teacher's next question) were decided by the teacher. In addition, it should be noted that although "interest" and "exploration" have a positive connotation, this assertion is neutral on the question of the value of the activity. The unknown student who intentionally flooded the Minecraft Hill Community, for example, took an interest in damaging the work of other people and likely investigated methods by which they could achieve that goal. Similarly, the steps to explore a phenomenon may not meet someone else's definition of what constitutes sufficiently rich exploration to "count" as learning. For example, a boy named Marcus used Kerbal Space Program but remained at a basic level, merely flying and landing the same shuttle over and over. Mr. Jacobson continually encouraged Marcus to experiment with other levels of the simulation, but he declined.

[19] De Garmo (1911: 59-60), however, does relate an account of a schoolmaster who generated interest in chemistry by staging explosions for students.

Assertion #2: When Students Started A Project, They First Organized Networks of Resources That They Then Used As A Basis For Their Subsequent Activity

When students sustained their focus on some phenomenon, they *started a project*, organizing networks of people, objects, technologies, and ideas out of which their subsequent activity would develop. These included, first, *material* resources: concrete or digital objects that would be used. After deciding to follow a project she had found online that called for her to build a chair out of cardboard, Maxine scoured the STEAM Lab for cardboard and duct tape that would enable her to start building. Cecilia opened up the Minecraft software and secured a space on the class Minecraft server in order to being building a utopian community. Franklin set out two computers as he looked for “cool circular buildings” on Google Images on a laptop and worked in SketchUp on a desktop computer. Students actively sought out the components that would allow them to build and furnish their physical and digital structures, as when Max accessed the 3D Warehouse in SketchUp to find furniture. With material resources secured, students looked for resources that would provide *procedural* guidance—the “how” of the activity. Here, Latour’s (2005) guidance to view human and non-human actors symmetrically is useful. Students sought out textual instructions, searched for online videos, and identified friends who could provide answers to their questions. Although these actions occurred through different modalities, the text, video and friends each served an identical purpose: establishing a network of resources that would show steps that were required. Ellen and Kyle returned continually to the how-to videos that showed them the procedure for assembling the car. Before starting his Kerbal Space Program project, Jon stationed himself next to Aaron (*see* Figure 8) with a direct sightline to Aaron’s work, and initiated a series of questions about how to set up a satellite relay system:

Figure 8. Jon (center) watches Aaron (right) build a satellite relay in Kerbal Space Program.

Jon:	*[Studying Aaron's screen]* You have a big relay.
Aaron:	Yeah.
Jon:	So you transmit from the small relay to the big relay, then it goes back. … Why do you have that?
Aaron:	So I can transmit data if I want to go to different places.
Jon:	How do you change [the satellites' configuration]?
Aaron:	*[Pointing to indicate screen controls]* See, my apoapsis is up there, and my periapsis is right here. So I'm going to rotate my periapsis.

Aaron's computer screen, his movements with the mouse and keyboard, and his explanatory talk and gestures constituted a connected set of resources that would allow Jon to design his own relay system, and specifically to execute the procedure for changing the configuration of the satellites. When Jon returned to his work station, he continued to draw on Aaron's expertise by occasionally calling out questions and to return to Aaron's station for additional observation. That is, he drew on a network of resources that he had established. Whether the "how-to" resources took the form of narration by a more-expert peer, demonstration on a video, or step-by-step directions from a written document, students found ways to bring themselves into contact with a collection of resources they needed to advance in a project.

This type of agentive work to locate and secure resources is, of course, a “natural” pattern of behavior when people are pursuing goals that are important to them (Stevens et al., 2008), notable here precisely because school often places restrictions on students’ attempts to find and use resources. Students might all be required to use the same resource, for example, or their efforts to use one another as resources may be considered cheating. In the 8th grade science class I observed, the teacher posed a problem about solubility, whereupon two students moved their laptops next to one another and began to propose possible solutions. This drew a sharp correction from their teacher, who assumed they were socializing (“Ladies, stay with me, please!”).

Figure 9. Organizing social and material resources: Franklin repositions his computer and engages Kira as an instructor.

Resources could be obtained and brought to a work area; alternatively, students could move themselves into a position where resources could be utilized. This involved moving to an area of the room where a particular resource (such as the teacher, or a friend with experience, or an instructional video) could be found, or arranging themselves within a small group so as to create direct lines of sight to a material or procedural model (*see* Figure 9). An especially common technique involved students arranging multiple computers, or multiple windows within a single computer screen, and sitting shoulder-to-shoulder, to have access to many resources at once (*see* Figure 10; Penney, 2016.)

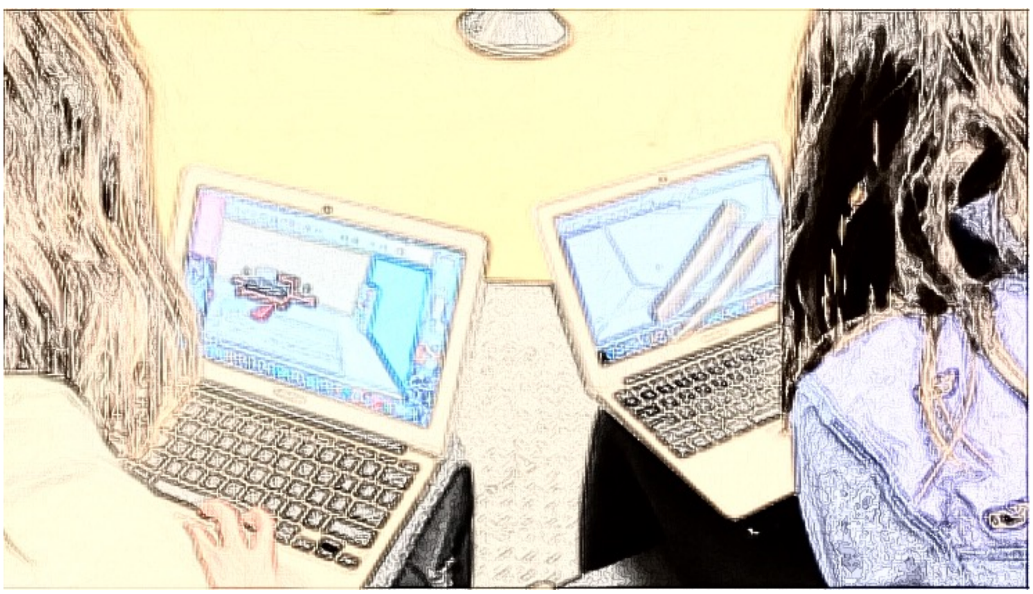

Figure 10. Working shoulder-to-shoulder.

Assertion #3: Students Worked From Material and Procedural Models

Reuse with transformation of structures made publicly available through the actions of earlier actors leads to the progressive accumulation, with locally relevant modification, of structure inherited from predecessors, a process that sits at the heart of human action.

Goodwin, 2018: 23

In one way or another, all of the artifacts created and the procedures used in the STEAM Lab—that is, all of the work that was done—had its origins in some material or process that already existed. Students tried to construct a thing they had seen, or to do for themselves an action they had observed.[20] This effort—seeking to reproduce, recreate, replicate, or re-enact what they had seen—drove activity forward, surfaced new problems that needed to be solved, and led to the development of new skills. "Failure" meant that whatever the student had made or tried to do did not match, to their satisfaction, a model of a physical structure or action they had identified. Students then sometimes "innovated" (as described in the next assertion) by changing, modifying, and improving existing forms in reaction to a felt need.

For example, 8th grader Franklin worked on a FUSE challenge called DreamHome, in which students learn the architectural design software SketchUp and create and furnish buildings. Franklin explained that he had "always" had a "passion" for circular structures and did a Google Images search for "cool circular buildings". Scanning his search results and seeing pictures of a "Tornado Tower," an office building in Qatar, he began a difficult effort to create a version of the Tornado Tower in SketchUp.

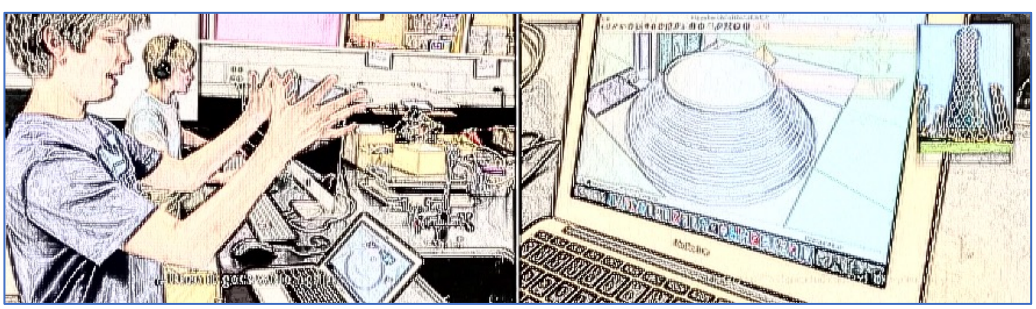

Figure 11. Franklin reproduces the Tornado Tower.

Left. Franklin gestures to illustrate the desired concave shape of his tower.
Right: Franklin's SketchUp work in progress.

[20] The "material" or "process" that became a model for the work could be either concrete or virtual, that is, students found them online or saw them physically in the STEAM Lab.

Right/Inset: Franklin's model: The Tornado Tower, a high-rise office building that Franklin discovered through a Google Images search for "cool circular buildings."

Franklin: That curve, it's unusual. … I'm trying to recreate it … but I don't know how to do that [in SketchUp] [to create] a perfect curve. So I'm just letting it have these little steps, like a pyramid.

Franklin's inability to manipulate the software to match the curve—to successfully reproduce the model he had seen—led to a workaround (Alter, 2014) very similar to that of another student who sought to recreate an architectural structure in digital form. Duncan and two friends had decided to build a coliseum (*see* Figure 12). They did a series of Google Images searches to find images and blueprints as references, then divided up the work and built their coliseum. Duncan provided me with a narrated "tour":

Figure 12. Duncan demonstrates his Minecraft coliseum.

Above Left: Duncan's Google Images search for "coliseum".
Above Center, Right: Reference models that the team used; Duncan gestures to show the curved edges that were difficult to replicate.
Below: Views of the Minecraft coliseum designed by Duncan and his colleagues, including an exterior aerial view (left), a view from the pit (center), and the interior concourse (right).

Duncan: So, this is our Coliseum. It took us a while. That's where they fight on the inside, these are the private places. This is the entrance. We're going to put some stands, for tickets and stuff. We're going to have a room right here for the gladiators. The gladiators will come out from here and also back there. This is the fighting arena.

Peter: *Is this what the actual Coliseum looks like?*

Duncan: Some of them. The Coliseum, the most famous one, doesn't look like this, but coliseums around the world will have the same design, the circle outside, and in the middle it would have the pits. And then they would have some private viewing, for the more rich people.

Peter: *How did you know what the Coliseum would look like?*

Duncan: We did research on what kind of coliseum we wanted to build. And what's actually possible. Because there's some lob arches, and in Minecraft you can't really build huge arches that well. So we went for a more basic coliseum with everything that a coliseum would have.

Peter: *What was the hardest thing about it?*

Duncan: Probably getting the round shape, and then building it up. You can't just build a circle, you have to make it, like, go into it [gesturing to represent blocks forming a curve].

Just as Franklin had tried to use SketchUp to produce a curved exterior wall of his Tornado Tower, Duncan had tried to create curved corners and lob arches in the Coliseum. Both students had a specific model that they tried to reproduce in digital form. This challenging complication became a problem to be solved, as the boys confronted their inability to precisely reproduce architectural structures and had to adapt. Unable to use the architectural design tools available to them (Minecraft and SketchUp) to create a smooth curve to match the models they sought to reproduce in digital form (the Coliseum and the Tornado Tower), each arrived at the same compromise: manipulating the square shapes available to them in the software in order to approximate a curve. As it happened, this act brought them into contact with a disciplinary idea from mathematics: the principle that as steps become smaller and smaller, they approach a curve. When Duncan reported that the hardest thing about the Coliseum was "getting the round shape," and noted that his adaptation was to "make [the blocks], like, go into it," he is gaining direct perceptual experience of a phenomenon that he will later encounter in high school calculus.

Duncan and Franklin were trying to copy structures from three dimensional space, but students also sought to copy two dimensional models. Cecilia, an aspiring artist whose case is presented later in this chapter, had drawn a dragon that included complex linework and detail. Asked how she had learned how to do that, she demonstrated how she had taped a drawing of a dragon above her computer at home and copied it (*see* Figure 13).

Figure 13. Cecilia acts out her explanation of how she learns to draw: by posting a model on her wall and trying to replicate it.

Language—precise terminology that described a material or process—was one way in which people created models for one another, as when a girl doing an interior design project suggested an "open plan" to a friend, Mr. Jacobson suggested that Jared add a "spoiler" to his cardboard drone, or Gavin proposed to "create a mod" in the Minecraft Hill Community. Students and Mr. Jacobson also used their bodies to create representations that they intended for others to use as models in their work. These usually took the form of spontaneous gestures that were synchronized with spoken utterances (Kendon, 1997; McNeill, 2008). Such natural, synchronized gestures were pervasive in the STEAM Lab. Mr. Jacobson, in particular, used them extensively as he communicated with students, such as making a parabola shape with his hand and arm to show the trajectory that a marble should take as it crossed an obstacle in a course that students were building. Kira, teaching two boys how to make a fidget spinner, used her hands extensively as she taught them to produce the fidget spinners they wanted (*see* Figure 14).

Figure 14. Kira uses her hands to model the shape of a fidget spinner.

The act of trying to recreate material or procedural models led the development of new technical skills. Kira wanted to make a fidget spinner modeled on the ones she had seen her friends using and had no choice but to learn TinkerCAD in order to make it. Max wanted to make a professional-quality interior design to resemble what she had seen at her house and friends' houses, and had to learn SketchUp to achieve this. Gavin wanted to create a text-based computer game like the ones he had played many times at home, and accordingly had to investigate the capabilities of the coding blocks in Minecraft. Students' inability to recreate models led them to seek out new technical skills that further increased their control over features within the software. At the same time, they did not always develop these skills or discover these features, and their workarounds (Alter, 2014) may indicate a limitation in structured-choice learning that is less present in direct teacher-led instruction. After observing Franklin's inability to create a smooth exterior curve (which he had resolved through a layering of progressively narrower circles), I investigated the capabilities of the SketchUp software. It did in fact include a feature that would have allowed Franklin to create a curved wall, and a skilled instructor would have shown Franklin how to do this rather than allowing him to settle for his invented compromise.

Assertion #4: Students "Figured Out" Material and Procedural Aspects of Their Project

I like figuring things out. *Jenna*

The expression *figure out* recurred constantly in Tech21. Students used the phrase routinely in conversations with each other and with Mr. Jacobson, in their thinking-out-loud as they worked on their projects, and in their conversations with me:

I'm figuring out how to make the circuit they want me to make by watching the video. *Maxine*

[On how he learned a software procedure] I figured it out just by starting to press buttons. *Kevin*

I need to figure out what to do with that empty space. *Max*

In one sense, the term *figure out* is simply a casual conversational shorthand used to indicate that some problem needed to be solved. Looking at the occurrences more closely, however, I determined that students used it to describe a phase of action in which they were investigating either the steps needed to produce a desired outcome (procedure), or the object that they needed to obtain or wanted to produce (material). Examples of each appear in Table 4.

Figuring out: Procedures	Figuring out: Materials
"how to change the width"	"what the tools are"
"how to use the program"	"what to do with that empty space"
"how to design something and print it"	"how to design the set"

“TinkerCAD”	“a way to make the base of my chair stronger”
“how to make the circuit”	“where all of this goes”
“a way to make it the same size”	

Table 4. Examples of phenomena that had to be “figured out.”

When Max spoke of figuring out “what to do with that empty space” in her virtual living room and Hailey spoke of figuring out “what the tools are,” each had concrete objects in mind as the outcome of *figuring out.* Max did not mean that she didn’t yet know the process by which she could make her furniture selection; instead, she meant the material outcome of that process (e.g., a couch and table). Hailey wanted to know exactly which tools she needed, and not instructions on a method for identifying tools. Although Robby spoke of figuring out “how to design the set” for an upcoming theater production, he said this while searching Google Images for concrete visual ideas, not procedures for designing theater sets. In these examples, *figuring out* referred to the identification of a fixed, material object.

In contrast, when students used *figuring out* in a procedural sense, they meant that they needed to identify a sequence of steps or transformations that would allow them to achieve a goal. When Maxine spoke of watching a video to figure out “how to make the circuit,” she meant that the video was providing step-by-step instructions on how to connect wires, not that it was offering her a selection of possible circuit design ideas. When Brandon wanted to figure out “how to change the width,” he meant that he needed to know the order in which to interact with certain parts of the TinkerCAD software in order to achieve an outcome: e.g., clicking on his design, then using a drop-down menu, then keying in a value for diameter.

However, material and procedural “figuring out” were connected. Procedural “figuring out” involved *embodied, spatial practice*, typically a coordinated sequence of hand-eye movements necessary to use software or a handheld tool. Seen in this way, the seemingly different meanings of *figure out what to do with this empty space* and *figure out how to make the circuit* both involve forms in space: one as a single, fixed image (e.g., a couch and table), the other a series of images in sequence (e.g., a hand in position to manipulate a wire, followed by the placement of a wire in a certain spot).

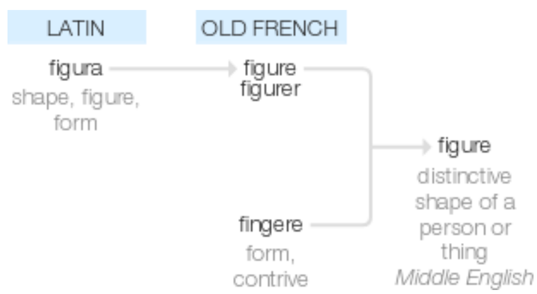

Figure 15. Etymology of "figure." Source: Google.

Support for an interpretation of *figure out* as ultimately involving embodied, material phenomena may be found in the etymology of the word "figure." The root of *figure* is spatial, involving shape and form (*see* Figure 15). Just as a new reader is advised to *sound it out* by giving sound to an unfamiliar word so as to give it meaning, students in Tech21 would *figure it out* by giving shape and form to an unfamiliar phenomenon or practice. They did this through trying it themselves, watching videos, watching other people, reading instructions that provided concrete details, and making models. That is, they looked for *figures*: tangible, concrete shapes and forms, either static or in motion (dynamic), that served as models for the goal they were trying to achieve.

Assertion #5: Students Produced Creative Innovations After Experiencing Unmet Aesthetic Or Functional Needs

Simply reproducing a model was often enough for students. Many who wanted to make a fidget spinner, for example, were satisfied to download an available template, learn the basic steps to 3D print the template, and thus fabricate a spinner. Their fidget spinners did not show any variations from downloaded model and did not show substantial originality relative to the fidget spinners that other students at Eagle Lake carried around. Similarly, many Tech21 activities, especially the FUSE challenges, included step-by-step textual or video instructions that most participants were content to simply reproduce. The light-powered car challenge, for example, required students to assemble the car and make it travel 5 feet; I did not observe any students assemble the car other than as instructed, nor did they set up obstacle courses or vary the challenge in any way. Sometimes, however, the model was not enough, and students made changes to the forms that were available to them. These variations were examples of what Mr. Jacobson called *being creative* or *innovating,* and he particularly valued and praised such variations.

Innovations on procedures. One of the FUSE challenges, "Coaster Boss," called for students to construct a roller coaster using segments of foam tubing. I observed a pair of 8th-grade boys, Chet and Lance, as they started with the materials from Coaster Boss, which required them to cause a marble to go down the track and achieve a certain speed. Chet and Lance tried the FUSE challenge a few times but then veered in a new direction, engaging in "productive deviations" (Hilppö et al., 2016). The boys rearranged the materials and set a new goal: getting the marble to jump off a ramp, land on a half-pipe, and ultimately roll into a small target.

Peter: *Wait, so what are you guys doing?*

Chet: It's an accuracy coaster. The goal of Coaster Boss is to get it the fastest. We didn't worry about speed though, we went for accuracy.

Peter: *Is that part of FUSE?*

Chet: No, it's our innovation.

Peter: *Why did you change it?*

Chet: Because it was our vision and we just decided to go for it.

In this example, Chet and Lance started by reproducing an existing material and process: the resources and steps set out for them in FUSE. It is not completely clear why they developed their innovation—Chet called it "our vision". Lance later explained that he was a snowboarder ("I love half-pipes, I shred on 'em") so the new activity may have been an effort to satisfy his interest in recreating his outside hobby in the STEAM Lab.

Innovations on material forms. Students spoke of wanting their creations to be "cool," "interesting," "different," "modern," "not boring."

> I kind of cheated a little bit, because I took an original, like a regular boring [fidget spinner] like Franklin's, and then I made it like interesting. *Kira*

> We both thought together to do something different than normal [with the spinners]. *Franklin*

> Sometimes I just go through [Minecraft] trying to find other programs, just to see. If I'm going to make something in here, I don't want to make something that's already been made. *Gavin*

For Franklin, this meant choosing to create a building in SketchUp with a curved shape, rather than the rectangular buildings that all other students produced:

> I've always liked circle stuff. Because basically everything we see [around us] is basically square, boxy, and I think a little boring. Circular just has a little twist in it.

For Duncan, it meant choosing to build an ancient structure, rather than the modern buildings that his classmates had chosen:

Peter: *Why a coliseum?*

Duncan: It was just a fun thing to build. No one made something ancient. There was no ancient buildings [on the class server]. Other kids had football stadiums and

> regular houses, but there was no ancient stuff. Nothing Greek. So we thought it would be cool to build something different.

For Kira, making it "interesting" meant adding small, spiked extensions around the outside of her fidget spinner.

These were *aesthetic* requirements, but students were also motivated to innovate when available forms did not meet a perceived *functional* need. Jenna, feeling sad and anxious about her upcoming move to England and separation from her friends, explained her decision to make a new kind of necklace:

> There are best friend necklaces, but there's not one for a whole group of friends or a whole family. So I wanted to make a friendship necklace for my whole group of friends.

This functional goal of a necklace that would memorialize her friendship after her move led Jenna from reproducing an existing model (a "best friend" necklace that only signified social connection between two people) into a creative innovation (a new kind of necklace in the form of a jigsaw puzzle, to achieve her goals of signifying connection among multiple people). Cecilia, happy with the aesthetics of her mandala, identified a new functional goal: displaying the mandala in a new medium, not just on paper. Accordingly, she sought to connect her design with other forms with which she was familiar, tattoos and T-shirts:

> I like to draw mandalas. I do an entire page of one. And now I'm thinking about trying to convert that into a tattoo, a temporary tattoo. Trying to figure out how that could go on your arm. Maybe converting that design into a T-shirt or something.

Just as Jenna moved to combine a necklace with a jigsaw puzzle, Cecilia's next step would be to integrate the two forms into a single work that connected two models: a mandala that was also a tattoo. Research on creativity shows that it results not from flashes of artistic insight but from a step-by-step progression of concrete moves to combine existing known entities; making novel associations between familiar forms is at the heart of the creative process (Sawyer, 2012; Weisberg, 1986; early theorizations of the creative process include Bain, 1855).

Innovations in response to adverse acts. A curious phenomenon occurred several times in the STEAM Lab, which I describe here because one instance of it led to a creative innovation. I observed at least three examples of students' work being intentionally damaged or destroyed by other students. Maxine was building a chair out of cardboard, as described later in this chapter, only to find one day that someone had taken a scissors and cut up the slats she had been making. Kira's fidget spinner, which is the focus of Chapter 4, was also broken by some unknown student, which distressed her considerably and which she continued to be upset about when I spoke with her in our final interview months after the conclusion of the class. The Minecraft Hill Community was flooded by someone who logged into the class server and redirected a river so that it flowed into an opening in the structure. Neither Mr. Jacobson nor the students nor I knew which student or students were responsible.[21]

When this intentional damage occurred in the class's Minecraft environment, students called it *trolling* or *griefing*. Although these terms had specific meanings in the multiplayer gaming worlds that students participated in outside class, in Tech21 "trolling" meant creating minor irritations, while "griefing" meant causing significant destruction to someone else's structure. Like Maxine and Kira, the Minecraft Hill Community builders—Jonah and Lawrence, who had recently been joined by Gavin—were upset about this griefing, which took a full class period to repair. Notably, however, this adversity led to an innovation by Gavin that both served his own interest (protecting the structure that he now had a hand in building) and further

[21] I suspected two people. One was Marcus, a socially awkward boy who, unlike Gavin, had been unable to find his way into a desired collaboration with higher-status boys. The other was Jason, whose class-clown public face and limited participation in the STEAM Lab projects masked, I believed, an insecurity about being unable to learn the software tools that he saw his friends learning. It is possible that one or both of these students secretly engaged in destructive acts out of their frustration with their own lack of full participation in the activity of the class, although this is strictly speculative.

solidified his emerging social position relative to two popular older boys, as described later in this chapter. Gavin's innovation was to write a "mod," code that would create an improvised security system at the perimeter of the Minecraft Hill Community. In Gavin's design, anyone with a username other than his, Jonah's, or Lawrence's who was detected crossing over into the Minecraft Hill Community would be turned away. Although it wasn't clear to me that this system ever became functional, his work to figure it out improved his skills over Minecraft's mod capabilities. It represented both a procedural innovation (the coding steps needed to develop this modification) and a material innovation (an invisible security fence around the Hill Community). These innovations and corresponding development of Gavin's skills occurred in response to an authentic need: to protect his and his peers' work from further destruction.

Assertion #6: Students Gave Their Work To Others To Achieve Social Goals

Having produced an artifact, students sometimes then made that artifact available for others to see, use, or take for themselves. This was done either implicitly, as when Robin and her friends worked in parallel on SketchUp such that each student's work was available for inspection by their partner at all times, or explicitly, as when a student gave a peer or Mr. Jacobson an artifact or picture and expected that he would comment on it, so that they could improve their work: Joe presented his fidget spinner to Mr. Jacobson, who felt its weight and explained to Joe that he should re-print it at 100% density, to create a heavier spinner. On many occasions, students simply gave their work to other people. They had many reasons for doing so. Sometimes, the reason appeared to be some form of straightforward altruism: Jared, for example, explained that he had made spinners for others out of a desire to see them not waste their money. Students also gave away their work simply because it was there and they had no need for it. For these students—such as Maxine, who gave her cardboard chair to Mr. Jacobson—the appeal of the activity had been in the work itself, not the work product.

Most commonly, however, the act of giving served some purpose for the giver. Kira made fidget spinners for her teacher and friends and took evident pride in their approval and appreciation. Jenna, as described above, made friendship necklaces to give to her friends, "to make something for all of us so we could always be connected in some way." The necklace served Jenna's purpose of ensuring that her friends would remember her after she moved away. This goal of creating a sense of permanence around experience similarly motivated Jon, who used a 3D printing pen to make a model of the Eiffel Tower to give to Mr. Jacobson. Jon explained his gift:

> Because it's kind of cool when kids give stuff to the teacher. Because then they will remember you and tell the story. Usually teachers don't remember you.

For Gavin, the act of making for others was socially strategic, giving him a pathway into a group of higher-status boys. On many occasions, he would remind me or Mr. Jacobson that he was participating in their activity. For example, when Mr. Jacobson would approach and begin directing questions to Jonah and Lawrence, Gavin would immediately come over and join in the answers. When I asked Gavin "what's up?" he would frequently begin his answers with "Me and Jonah and Lawrence …" or "I'm working with Jonah and Lawrence on ..." I asked how his came about:

> **Peter:** *How did you get to be part of this group?*
>
> **Gavin:** These guys were having trouble finding their base [in Minecraft], so I made them a little passageway from Spawn so they wouldn't lose their way.

Gavin's response confirmed what I observed. Overhearing them having trouble locating their base when they logged in at the start of class (an unmet need), Gavin's innovative technical solution had the benefit of earning their respect, which was communicated through a nonchalant acceptance of his proposal. After the Minecraft Hill Community was flooded, creating a need for security, Gavin's alarm system represented another innovation that further solidified his position within the group. Innovation, in other words, served two unmet needs for Gavin: the emergent technical requirements of the Community as well as his craving for acceptance by higher-status peers.

Assertion #7: Students Received Feedback From Peers Or Their Teacher, Then Decided Whether To Continue Developing A Project Or Line Of Practice

As students completed either a work or a step in a work, they received feedback from their peers or from Mr. Jacobson. This feedback played a role, in both a small and a large sense, in determining whether and how the activity would continue. By a "small" sense, I mean that students sometimes used the feedback to guide material modifications to their work or make changes to their work process. By a "large" sense, I mean that their participation in a project was motivated through ongoing feedback, and the trajectory of a line of practice was sustained and sometimes altered as a consequence of the feedback.

Material and procedural feedback. Responses from peers to work-in-progress typically occurred on short, moment-to-moment timescales, as when Franklin presented a provisional spinner design to his classmates:

1	**Franklin**	*[Turning his screen to Kira and Joe, who examine Franklin's spinner]* Does that look cool? Is that how you do it?
2	**Kira**	*[Shrugging; pursing lips; shaking her head]* Sure.
3	**Franklin**	No. I take that as a no.

4 Kira *[Turning back to her measurement work with Joe]*
No, it's whatever you want it to look like.

This exchange illustrated feedback as an embodied, multimodal phenomenon that sometimes involved complex decoding on the part of the recipient. Despite her stated approval of the design, Kira's body language—pursing her lips, shaking her head "no"—demonstrated what was interpreted by Franklin as disapproval. Kira did try to repair her feedback at line 4 with a clarification that Franklin should use his own aesthetic standards to decide on the suitability of his design, as she closed off the exchange by physically turning back to Joe. Kira's feedback to Franklin was not particularly encouraging, but his interest in the project overcame her indifferent reaction. Moment-to-moment feedback occurred in the Minecraft Hill Community, as Jonah and Lawrence would glance at each other's work and say "I like that" or "cool, maybe use a different color." A group of girls using SketchUp to design the interiors of their dream houses would regularly show their screens to one another and receive friendly, quick suggestions such as which couch to select or where to place a bathroom sink. Procedural feedback—guidance on the "how" as opposed to the "what"—commonly occurred in response to specific requests for help, such as how to use a sequence of mouse clicks to select a three-dimensional object. I only rarely saw students volunteer procedural feedback to one another without being asked, and this would occur only during joint work, when one person's misguided procedures were leading to a problem in a shared project. For example, I observed one student saying "you're doing it wrong" and stepping in to model correct procedure as the team launched a marble down a track.

Mr. Jacobson had recurring comments to give to students on their artifacts as he made his rounds through the STEAM Lab: he consistently wanted their work to be more realistic and less fantastic. Reviewing Cecilia's plans for her utopian community, he proposed an access route. Reviewing the Minecraft Hill Community in progress, he noted that the grass would not grow inside the boys' structure, and ventured, "What if we made it just a little more realistic?" Mr. Jacobson also gave feedback on student work procedures. As he observed students working, he frequently directed them to plan out their project before proceeding. He also advocated doing things more safely or efficiently, or proposed that one student provide help for another.

Feedback as motivation. Feedback often took the form of simple encouragement and enthusiasm from other students when an achievement was confirmed. Jared's cardboard aircraft took flight, to loud cheering from a group of friends. Chet shouted "Yes!" and gave Lance a high-five when their marble landed in the small cup they had set out as a target. (Not every form of feedback was enthusiastic, however, even at a moment of high achievement: Gavin eagerly showed his higher-status partners a Minecraft mod he had made that excited him—"I have fulfilled my purpose in life!"—only to receive a casual "cool" from Lawrence, who quickly turned around and returned to his work.) Students working in parallel in small groups, typically on architectural design software, appeared to use casual, moment-to-moment feedback about their work as ongoing motivation to continue a project; these ongoing supportive social exchanges seemed to be part of the "fun" of the activity as many students reported to me that they liked working with others. Within-project motivational feedback was often provided by Mr. Jacobson, who routinely provided verbal feedback as he informally observed the work products of students. Watching Aaron assemble his satellite relay system, Mr. Jacobson mused: "That's just absolutely incredible, I love what you're doing." He often provided high fives and pats on the shoulder as he encouraged students.

Responding to feedback. These evaluations, whether subtle body language from a peer inspecting an artifact, or a comment from Mr. Jacobson about making a sketch next time, usually served as resources for students in a next round of construction. Students could choose to revise their constructions, as Franklin did in adjusting the shape of his spinner, or make new ones, as when the a girl working on SketchUp decided to make a Jack and Jill style bathroom after hearing the suggestion from a friend. This step meant that students returned to the "model" step in process described above; the feedback from a peer or the teacher constituted a new addition to the model that was guiding the student's work. Alternatively, students could simply ignore the feedback: only rarely did students accept Mr. Jacobson's procedural advice to make plans and sketches.

Terminating projects and extending or switching lines of practice. Although I had expected to observe scenarios in which negative or neutral feedback led students to terminate a project, I did not in fact see such scenarios. Students seemed to end a project when it had been completed to their own satisfaction and they were ready to move on to something else, when they were bored and ready for something new, or when their peers were doing something they wanted to be involved in. Gavin switched away from a half-completed Eagle Lake Town Hall to join the Minecraft Hill Community, ending one project but continuing his line of practice as a coder. Maxine finished making a light-up shoe and moved to the cardboard chair as described below. This represented an ending of one project and an initiation of another, but also a continuation of her line of practice as an engineer. Similarly, the students using SketchUp to design their dream home would complete one home and then move onto another—a beginning and end of a project but a continuation of a line of practice as a designer. Students also ended lines of practice and started new or different ones. Cecilia, whose case is described below, spent 2 weeks working on a Utopian community in Minecraft. When this was completed, she turned to her drawing, a distinct line of practice that she then pursued for the remainder of the trimester.

As indicated above, the language of these assertions—innovation, feedback, goals, development—has a positive valence and suggests learning that is in some sense productive. A positive association with these terms is not required, however, in order for the model to be applicable. For example, had I witnessed the students involved in griefing the Minecraft Hill Community, I likely would have observed a process of noticing (perhaps jealously seeing the boys collaborating on an activity the individual wanting to join), innovating from a model (finding a new way to damage Minecraft environments), doing technical work (redirecting the river to flood the Community), being gratified by the feedback (seeing the peers be annoyed), and possibly continuing to damage other student work. All of this would be valued learning by the student involved, though certainly not valued by Mr. Jacobson or the students who had worked carefully to build the Community. In addition, the model is silent on the focus or complexity involved in each step of the activity. Kira reported that not all of her peers worked hard in the STEAM Lab:

> There were some people who were like, their project was like Minecraft. Really they were just playing around on Minecraft. They weren't actually doing it. Other people, like Maxine, she was making a cardboard chair. That was really cool and she was working so hard on that.

The students she was referring to included Jason, who (like Marcus on Kerbal Space Program) did not challenge himself to do advanced work in Minecraft. Kira assesses this as "just playing around." Jason did notice Minecraft as an activity to pursue, organized his work area alongside Amanda's, used her building as a model, asked her what she thought, and made changes. Because the work itself was not complex, and perhaps also because of Jason's lack of seriousness in pursuing it, Kira does not consider it productive learning.

Discussion: Learning through Constructive Interaction

In the previous section, I documented recurring practices that I observed in the STEAM Lab. I described a series of assertions, which I organized into a sequential paradigm model. Students scanned their environment and noticed an object or activity that became the focus of their visual and auditory attention. They advanced projects by organizing people and things as resources, identifying material and procedural models, and "figuring out" how to construct concrete and digital structures. They made changes that they thought made existing models "cool," "different," or "interesting," or that fulfilled an unmet need. They used the work themselves, or gave it to others, receiving ongoing constructive feedback on this work through interactions with their friends and their teacher, which set the stage for new rounds of planning, designing, building, and feedback.

I call this paradigm model *constructive interaction.*[22] Students learned as they constructed, in interaction with one another and their material environment. Constructive activity within a complex ecology of physical and virtual objects (Eisenberg, 2003) formed the basis of student activity in the STEAM Lab, from Kira's spinner to Chet and Lance's accuracy coaster to Robin's 3D-printed hall pass to Jenna's friendship necklace to Duncan's Coliseum to Ellen and Kyle's light-powered car. Acts of creativity—going beyond existing models into innovations and changes—involved literally being *constructive*: planning, building, modifying, and transforming objects as students tried to achieve their goals. If constructive activity formed

[22] I intend "constructive interaction" as a new construct with resonances in prior literature. In the field of human-computer interaction, "constructive interaction" is used to describe a research protocol in which two people work on a difficult technical problem and their communications during cooperative exploration of the problem become a source of empirical data (Miyake, 1986; O'Malley, Draper & Riley, 1984). This sense of constructive interaction suggests the research method used in this chapter: studying learning in naturalistic contexts by watching and listening to people as they interact around an artifact or a technical system. My use of the term also intentionally recalls and embraces cognitive constructivist perspectives on learning, as well as symbolic interactionist perspectives from sociology.

the substrate, however, it was the *interaction* within practice that moved projects forward for most learners in the STEAM Lab. Learning in the STEAM Lab was "constructive" also in the sense that the culture was positive, pro-social, and encouraging. A culture of teamwork—helping when needed, providing feedback, and giving or sharing ideas and artifacts with others—defined each of the classes I observed. The activity structure of Tech21, in which students were free to share ideas and actively encouraged to work together, led to the emergence of a culture of collaboration and communication in which processes of coordinated work and constructive feedback developed.

Such an environment has been documented other research on structured-choice environments (Ramey & Stevens, 2018; Stevens et al., 2016; Stevens et al., 2018; Ramey, 2017; Penney, 2016). This culture could be seen in Ellen's kindness and patience with Kyle, Kira's teaching of Joe and Franklin, Jared's friends cheering his successful flight, Cecilia's classmate praising her artwork, the SketchUp girls working shoulder-to-shoulder exchanging ideas and critiques, and in countless other examples I observed every day. Even where acts of destruction occurred, such as the trolling and griefing in the Minecraft Hill Community or the damage to Maxine's cardboard chair, these tended to be followed by pro-social acts: Gavin worked on a security system for the Hill Community and Ashley and other students expressed sympathy for Maxine.

The experiences of Kira, Joe, and Franklin, which will be documented in Chapter 4, demonstrated the centrality of interaction among people and objects to the learning process (Stevens & Hall, 1998; Stevens, 2000b; Matusov, 1998; Engestrom, 1999; Latour, 2005). Kira taught Joe and Franklin in a process that involved extensive give-and-take, modeling, conversation, coordination of movement, and examination of the artifacts that each had produced. Similar processes of social and material interaction were pervasive in student work I observed, including the Minecraft Hill Community and Ellen and Kyle's light-powered car. Learning in the STEAM Lab was produced by participants themselves and made visible in their interactions (Stevens, 2010), as students mutually decided on the significance and meaning of learning activities (Blumer, 1969; Mead, 1934). Gavin's work to make a contribution to the Minecraft Hill Community represents an example of this. While Eagle Lake offered a coding class that provided a mechanism for Gavin to be recognized by the school for his achievement, the form of expert computer practice that was valued by his peers instead involved modifications and enhancements that improved their Minecraft world. Gavin's ability to design "a little passageway from Spawn" that helped the boys locate themselves in their world was the form of knowledge that they valued and that allowed him to achieve his goal of full participation in their Hill Community.

The constructive interaction model describes the learning experiences that I observed in the STEAM Lab. One goal of qualitative ethnographic research is to produce a model of a recurrent, locally observed phenomenon and to consider the question of "generalization" by asking whether that model represents "a process, the same no matter where it occurs, in which variations in conditions create variations in results" (Becker, 1990: 240). By studying the phenomenon in other contexts and using the model as a lens, the researcher can investigate whether the model has explanatory power. Here, I suggest that the constructive interaction model may have some *predictive* and *diagnostic* value and that it may be used as a *resource for design.*

First, the theory has some predictive value. When the two essential conditions of a structured-choice learning environment are met (ability to choose, combined with the ready availability of material of interest to students), students will generally proceed through the steps described in the model. They will scan their environment, focus their attention, organize resources, find models, develop new skills, figure out how to solve problems, and construct artifacts. A culture of student interaction—feedback and mutual assistance—is likely to emerge (Ramey & Stevens, 2018; Stevens et al., 2016; Stevens et al., 2018; Ramey, 2017; Penney, 2016). This finding addresses an objection to the implementation of structured-choice learning environments: educators, parents, or administrators may be concerned that providing students with a measure of freedom cannot lead to learning in light of students' presumed "indifference, indolence, and want of discipline" (Knoll, 2012: 36). This chapter, and the research cited above, provides reason to believe that productive activity will result.

Second, the theory has diagnostic value for student failures. When a student stalls in momentum or has trouble initiating projects, the model suggests places to look. The student may not have found any of the available options in the environment interesting enough to pursue; the necessary resources may not have been available; the student may have been unable to locate and figure out the appropriate models; the tools may not have enabled them to recreate the available models. For example, Kira discussed with Mr. Jacobson her idea of designing a homeless shelter in SketchUp. He suggested that she "do research." Kira responded: "I don't know where to start, that's the problem. Literally, for everything I do, I always need some place to start. I can't just say, 'I'm going to start.'" Kira made no progress on the homeless shelter; in contrast, she had quickly acquired the complex skill of TinkerCAD to make her spinner. The constructive interaction model suggests that the difference between her failure to create the homeless shelter and her success creating the fidget spinner may be found in the *organizing resources* phase. Kira had ready access to a critical resource on the spinner project: the concrete demonstration in the how-to video from FUSE. In contrast, she had no equivalent resource to draw on to respond to Mr. Jacobson's proposal that she "do research, Google some things that are out there." Although many Eagle Lake students could have made the inferences Mr. Jacobson expected Kira would be able to make (e.g., known exactly which search terms to use and how to turn the results page into a basis for further action), Kira was not able to do so. Even highly successful students, however, ran into problems during the *organizing resources* phase: Maxine's work on the cardboard chair came to a complete stop when the glue gun broke and no replacement was available, and she instead took apart the broken glue gun to examine it. Although a casual observer might have concluded that Maxine was choosing to waste time disassembling the broken glue gun, this action occurred only because her project was derailed by the lack of availability of a critical resource. Similarly, problems with *figuring out* may be traceable to a paucity of clear material or procedural models—forms that the student can try to reproduce. Expecting students to rely on textual or verbal instructions could be at the heart of an inability to *figure out.* This appeared to be the reason for the emotional breakdown experienced by Kyle while trying to create his year-end portfolio: the task of reproducing the steps needed to make the portfolio was simply too complicated for him.

Third, the theory may be used as a resource for the design of learning environments. The literature on interest suggests that students will move from the observation into the construction phase when activities involve extensive interaction with concrete materials; when opportunities for social interaction, recognition, and coordination are provided; and when activities provide pathways by which students can achieve self-actualization. Tech21 afforded this opportunity to Cecilia, who wanted to grow as a visual artist; to Gavin, who wanted to become a software engineer; to Max, who had a passion for interior design; and to Kira, who described a possible future as a designer and entrepreneur. Once this process has started, students will build momentum on projects when substantial resources are in the environment to be organized. This includes material resources (tools and supplies) and social resources, from which students may be excluded in various ways; an environment in which students are actively encouraged to help one another increases the resources available. Clear, readily accessible material and procedural models such as how-to videos and demonstrations should be provided in order to assist students in figuring out what they need to do. The task of reproducing models should maintain an optimal level of difficulty in order to motivate and sustain engagement and persistence (Csikszentmihalyi, 1990; Malone & Lepper, 1987). This difficulty may be designed so as to generate challenges that lead to the development of new skills (such as finding new capabilities in a production tool) or to application and development of disciplinary knowledge (such as solving problems of measurement and scale in order to achieve successful reproduction). Students should be actively encouraged to innovate by making improvements and modifications to models. A culture that encourages giving and sharing may lead students to sharpen their reproduction and innovation skills in order to win respect from peers. Feedback methods should "complete the circle" and function as formative assessment by providing concrete resources (material and procedural models) that serve as a basis for new rounds of activity.

In summary, constructive interaction is a model that describes learning in the structured-choice environment of Tech21. It may offer predictive and diagnostic value in the analysis of such environments and serve as a resource for design. It may also surface processes and phenomena that may occur in other settings, including traditional learning environments, in similar or different ways (Becker, 1990). My intention, in other words, is to provide a concept with the potential for theoretical generalization (Eisenhart, 2009; Becker, 1990). Eisenhart (2009) writes:

> A discouraging fact about education research in the United States is that few qualitative researchers pursue investigations designed to test or extend the theoretical generalizability of other qualitative researchers' conclusions. Few even attempt this with their own work. Emergent mid-range theoretical generalizations … [constitute] a point of departure for additional case studies and theoretical development. (63)

Applying the model to the analysis of environments, such as math or science classrooms, could provide the basis of a program of future research.

Ethnographic cases

I turn now from a general process model, derived from the data as a whole, to the particular: a selection of student learning stories or "cases" (Ragin & Becker, 1992). These exemplify the constructive interaction model, and I will use this model in my presentation and discussion of the cases. I sampled the cases in part as empirical examples of interest-based learning that accordingly represent opportunities to explore the early theorizing on interest (De Garmo, 1911; Dewey, 1913). Two of the cases, Cecilia and Kira, provide opportunities for connecting the early theorists' notion of "spiritual" development with modern conceptualizations of "identity" (Holland et al, 2001). I also sampled cases where the theory proposed by Dewey and De Garmo did *not* provide a satisfactory accounting of the student experience. The choice of the cases presented in this section was guided, then, by their detailed illustration of aspects of the constructive interaction model outlined above as well as by the opportunity they afforded to apply the framework proposed by early theorists. The first case, "The Cardboard Chair," shows Maxine, a student who identifies as an aspiring engineer, making a difficult technical accomplishment, but the case points to a gap in the early interest framework model presented earlier. The second case, "#squadnecklace," represents a vivid example of social connection and recognition as a motive for self-sustained activity. I sampled the third case presented here, "No 'I' In Team", because of its similarity to a case documented by McDermott (1996) of a student whose "learning disability" was less apparent in some contexts than others. The fourth case, "Cecilia, The Shy Person," vividly shows one student's organization of resources as models for her work and also represents an example of a student's developing identity as a practicing artist.

The Cardboard Chair

"Maxine," an 8th grader who told me she had a career goal of becoming an engineer, had taken Tech21 in 7th grade. She enjoyed it and signed up again:

> It's the only class in this school … that actually you can learn to do anything in STEAM, anything that you want to do. And it's good to find things that, if you want to be an engineer, you can narrow down on.

After spending the first two weeks in Tech21 working on an e-textiles activity—making a pair of shoes with lights along the sole—Maxine began to search for her next project, finally bringing an idea to Mr. Jacobson that she had found online.

Figure 16. Mr. Jacobson approves Maxine's proposal.

Mr. Jacobson: *[To researcher]* I just got really excited as a teacher because of what she showed me that she wanted to build. Because she said that there wasn't really stuff in [the STEAM Lab] currently that she was really interested in, she went through a bunch of other projects. She found this project.

Maxine: *[To researcher]* It's a cardboard chair. … You're allowed to have a pencil, a ruler, exacto knife, and cardboard, and you have to make a chair that works.

Peter: *How did you find that?*

Maxine: My sister did it, actually. She did it in an engineering class in high school. She did this and hers failed, but I will try it.

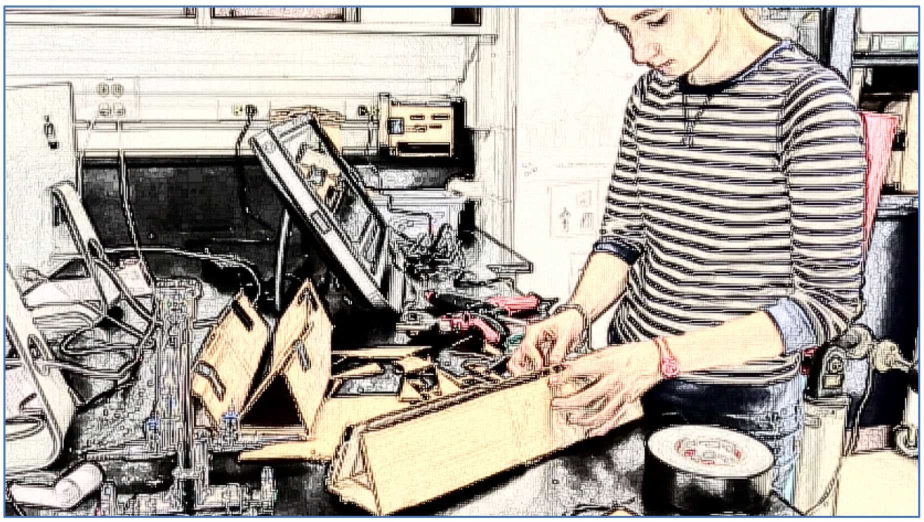

Figure 17. Using a cardboard cutter and duct tape to construct components of the chair.

Maxine then obtained materials and tools: sections of cardboard, a cardboard cutter, duct tape, blank paper, and pencil (*see* Figure 17). She alternated between making sections of the chair and writing down notes and measurements (*see* Figure 18) that would serve as ongoing references for her as she built the chair.

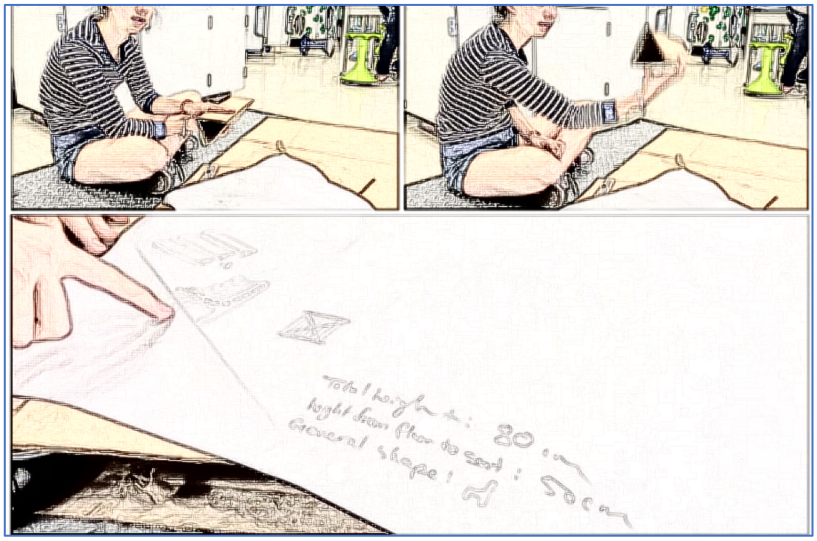

Figure 18. ***Planning out the chair.***

Above: **"**My plan is to make the sides, like this, one big piece, and then have pieces of triangles, have them like this into the big piece, so you can sit on this [*left*], and it will go all the way around [*right*]."
Below: Maxine's sketch showing the total height and height from floor to seat in centimeters, and a drawing of the general shape of the chair.

Maxine continued to work on the chair, assembling the 6 triangular components. She ran into an obstacle, however, when she needed to glue certain pieces together.

Peter: *How's the chair coming?*

Maxine: Pretty well. I just need the hot glue gun that Mr. Jacobson has to order. But I'm figuring it out. My plan is to make … I already have a lot of these [triangles] made, so I'm actually going to make 3 of these on each side, so it's thicker and stronger, and then have these in the middle … it's going to be more like a cardboard stool, but hopefully it will work.

In the exchange between Mr. Reilly and Mr. Jacobson presented in Chapter 2, Mr. Reilly had criticized Tech21, saying "I think a lot of what I see is there's not a whole lot of science and math being done." As Maxine was showing me her sketch, including the measurements, and demonstrating to me how the chair would support weight, I asked:

Peter: *Is there any physics in this?*

Maxine: Not really.

Peter: *Is there any math?*

Maxine: I mean, I guess you have to figure out what's going to hold up a person, but I didn't actually do any [math], and I wrote down how big each of them was going to be, but other than that I didn't really write anything down. … I don't really need … I don't know. When I have something in my mind, I know what I'm going to do, and I figure it out.

Maxine's understanding of the terms "physics" and "math," then, like Mr. Reilly's, did not extend to the emergent design and engineering problems she encountered on the project. The steps she described were working from a model ("when I have something in my mind," although she had also sketched it) and then figuring out how to make what she had pictured.

During the project, another student—Mr. Jacobson never identified who it was—intentionally damaged Maxine's work in progress as well as that of many other students. Maxine's work up to this point, unlike that of the majority of other students, had been individualized. She had no collaborators, though she explained to me that this was because she did not know anyone else in the class and would have preferred to work with others. When the damage occurred, however, other students entered the picture. Maxine showed the damaged cardboard triangle to her classmate Ashley and to Mr. Jacobson, who reacted strongly (*see* Figure 19).

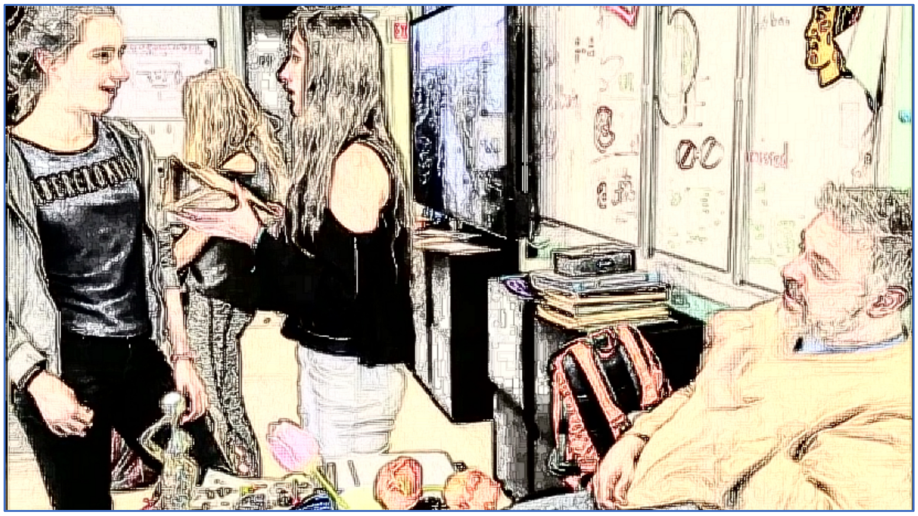

Figure 19. Maxine (left) displays damage to her work to Ashley (center) and Mr. Jacobson.

Mr. Jacobson: I'm about to lose my mind, because--

Ashley: *[Whimpering sympathetically to Maxine as she observes the broken part]* Ohhhhh!

Mr. Jacobson: -- this makes me sad. I see that a lot of people are messing with other people's things. I know that that totally throws off the structural integrity [of the chair]. I'm sorry.

Peter: *What happened to your chair?*

Maxine: Someone just … one of the triangle pieces, it looks like they were cut into and stabbed with a screwdriver and snapped in half. … It's kind of very annoying because that took a long time. … Because these are cut out in specific shapes … and so I probably will have to figure out a way to make it the same size.

The glue gun that she needed to repair the damage was broken, and Maxine continued to wait for several days on a new glue gun. In the interim, she picked up various informal projects, including the disassembly and examination of a broken label maker and the broken glue gun.

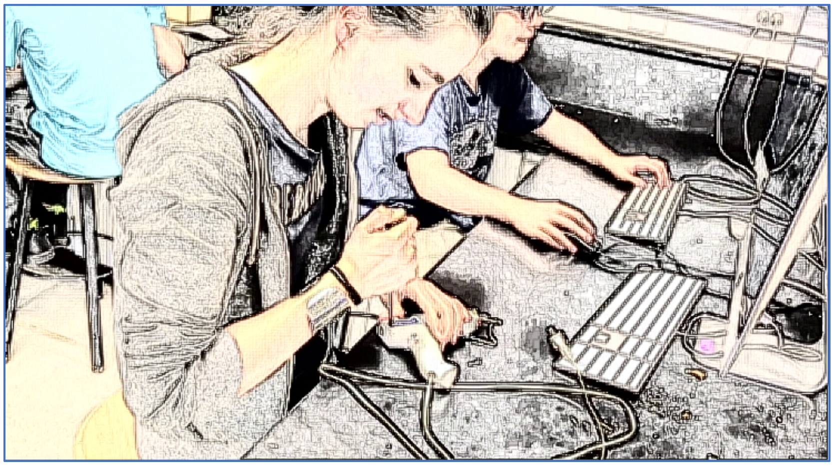

Figure 20. Disassembling and examining a broken glue gun.

Maxine: This [glue gun] is broken and I like pulling things apart and looking at them. So, until [Mr. Jacobson] finds a hot glue gun, I'm going to do this.

Here, the interest framework from De Garmo and Dewey is inadequate to account for Maxine's enjoyment of "pulling things apart and looking at them". As described above, technical objects and devices, especially ones with "powerful effects," fascinated many students. Maxine liked to discover their inner workings, part of her long-term line of practice as an engineer.

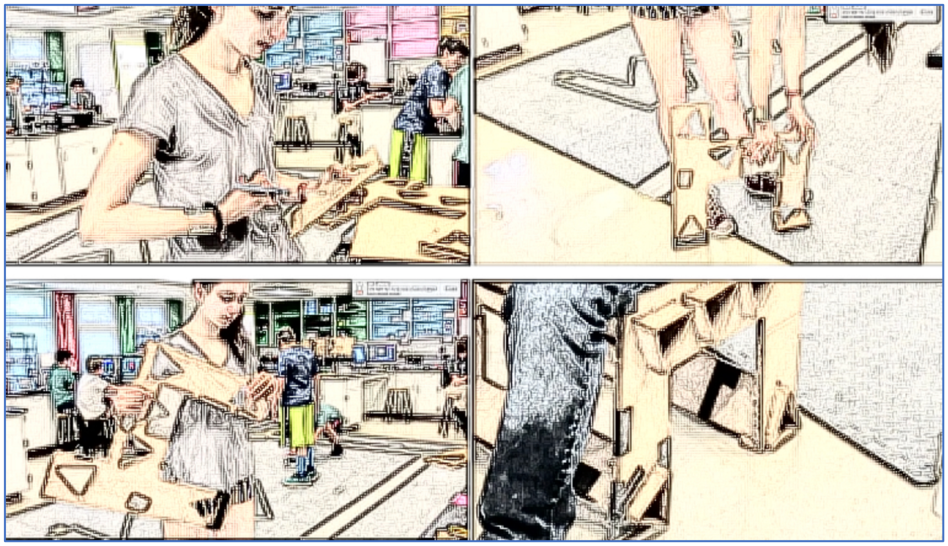

Figure 21. ***Troubleshooting the chair.***

Above left: Cutting holes into the frame to hold the triangles.
Above right: Discovering that the frame will fail at the feet.
Below left: Adding tape to reinforce the frame.
Below right: The reinforced chair.

After she was able to glue and complete the triangles that formed the seat of the chair, Maxine worked on the frame (*see* Figure 21). She discovered that the feet were not stable and made two modifications: using duct tape and adjusting the orientation of the triangle on the back two legs. Maxine's completed cardboard chair (*see* Figure 22) supported the full weight of an adult and was the subject of widespread admiration by her classmates, which Maxine appeared to take pride in.

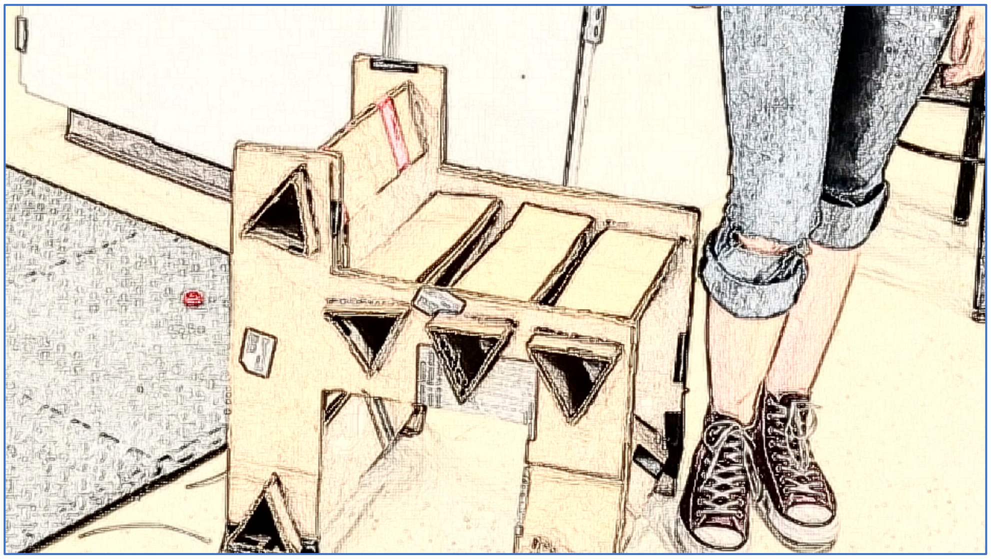

Figure 22. Maxine displays her cardboard chair.

Maxine's project had a notable impact on another student, Kira. At the end of the trimester, Kira spoke enthusiastically about her experience in Tech21. One of her most vivid memories was seeing Maxine work on her chair. Even though Kira had not been involved, merely observing it had been powerful for her:

> I learned that you can make a chair out of cardboard. Most people, they look at cardboard, and they're like, "no way you can make a chair out of just cardboard!" But Maxine, that's what she's done. And I think that's really cool. I'm seeing all these people doing so much cool things.

In summary, Maxine's story vividly exemplifies the constructive interaction model. She searched for a project and noticed the cardboard chair activity online, which she selected for its challenge (her sister had failed in a similar activity) and also because it afforded her an opportunity to develop a line of practice as an engineer. She assembled the materials, including cardboard, cutting tools, and chart paper on which she sketched notes and plans. She drew on ideational models—her memory of chairs she had observed. Collectively, the sketches, memories, and mental images enabled her to "figure out" the chair (to give it shape and form, in the sense in which people "sound out" a word or "rough out" the basics of a plan). Faced with the failure of the chair to support weight, Maxine's successful innovation was to reinforce it with duct tape and to reorient one of the triangle braces. Along the way, when resources (the glue gun) were not available, she was not able to proceed and instead occupied herself with carefully examining a novel technical phenomenon (disassembling a broken glue gun). When her chair was completed, she allowed other students to examine it and gave it to Mr. Jacobson as a gift. Although Maxine worked on this project more or less in isolation, the visibility of her activity became part of other students' learning trajectories within the community of the classroom: the complexity of her work and her focus served as a model for Kira, who was able to "see all these people do so much cool things."

#squadnecklace

8th grader "Jenna" was experiencing a personal crisis. She and her mother were about to move out of the country, which meant a permanent separation from her "squad," her friend group at Eagle Lake. Jenna scanned the available options in FUSE, noticed the jewelry-design challenge, and, motivated by the desire to memorialize her friendship, decided to make it her project: "I wanted to make something for all of my friends, and I thought it would be cool to make something for all of us so that we could all be connected in some way." She was familiar with various options for jewelry that would symbolize friendship, but none met her need, leading her to an innovation. Jenna explained in her reflection on the project:

> We were picking our projects … and I couldn't decide what I wanted to make. I knew I wanted to make something that I could give to my friends. One weekend I went to a store and they had friendship necklaces. I looked for one that all of my friends could wear but I couldn't find any. So I decided that I would make them. I needed something that all of them could fit together no matter who was there. I thought of magnetic hearts, but that wouldn't work, so the next option was something that could fit together. A puzzle piece that could fit together.

Jenna's innovation was a necklace in the form of a jigsaw puzzle piece; each piece would fit together to create what she would call a "squad necklace".

After organizing resources that included a computer, design software, tutorial videos, and pencil and paper, Jenna began working. Like Maxine, she made "kind of a rough sketch of it" that "just recorded where everything needs to be," giving herself a model that would guide her future action (*see* Figure 23). She encountered repeated frustration and failure in trying to design a shape that would match the model she had made for herself: "they won't fit together, and they're different sizes, so it's not working." This work to match her model also generated an accidental discovery that improved her skills. Frustrated by her inability to manipulate a control in TinkerCAD, she banged repeatedly on the mouse. This revealed to her the double-click feature in TinkerCAD, which causes multiple stacked elements to be selected as a group. Jenna laughed as she explained to me that after this accidental discovery, she had since used this technique regularly. As she made adjustments to the dimensions and scale of the necklace, she used math in response to emergent problems:

> I'm trying to get this to a usable size, because I printed it at 50 by 50, and it's way too big for a regular person to wear. So I'm going to make it 40 by 40, so, 20 percent smaller.

Jenna's casual application of a mathematical concept during practical problem-solving exemplified a goal of early progressive educators; Dewey's students, for example, used reading and mathematics when trying to use cookbooks and measure out ingredients (Knoll, 2014), and modern-day hands-on learning environments are designed to encourage similar applied problem-solving (Stevens, 2000a).

After 3 weeks of work, Jenna had a successful design, and 3D printed a set of interlocking puzzle pieces, each engraved with the word "forever."

Figure 23. Jenna designs and 3D prints a set of interlocking puzzle pieces.

Above left: Jenna's pencil-and-paper sketch for the friendship necklace.
Above right: Using TinkerCAD to modify her initial design.
Below: Displaying an early version of the necklace that printed out too large.

In accordance with Mr. Jacobson's policy, Jenna wrote weekly "reflections" on the project and created a Web page about it for the trimester-ending portfolio project (*see* Figure 24). Mr. Jacobson told me that Jenna's portfolio was "terrific." She received an A on her reflection, the portfolio and for the class as a whole, expertly "navigating" (Stevens et al., 2008) the institutional requirements for a high grade. Jenna's portfolio and her successful navigation of the course's grading requirements stood in contrast to that of Kira, who also developed expertise in TinkerCAD but whose course grade is the subject of Chapter 4.

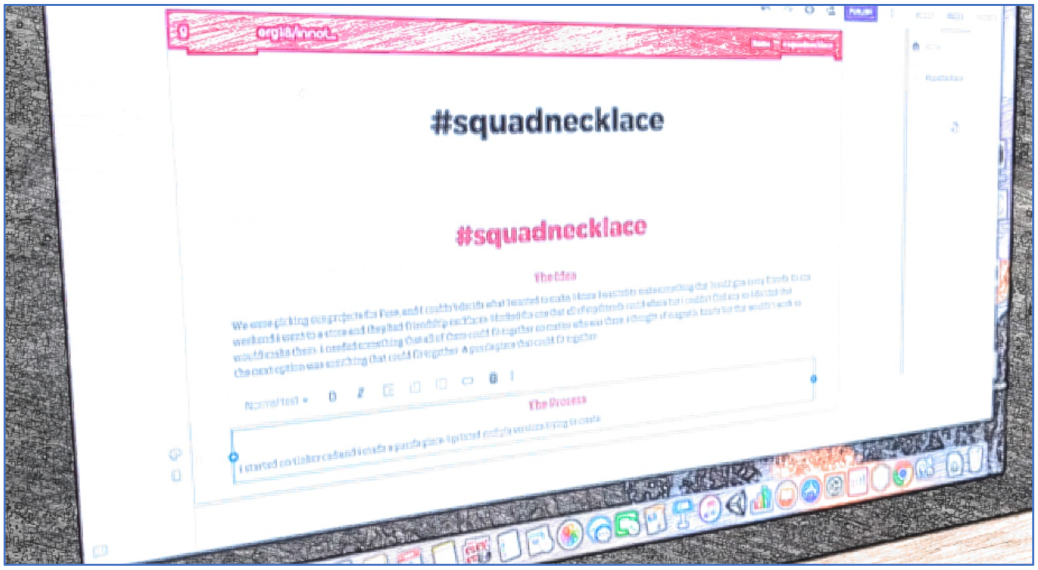

Figure 24. Jenna's assigned portfolio page for her project, documenting "The Idea" and "The Process."

Jenna enjoyed this work. Although the desire to memorialize her social network was the primary motivation, Jenna was also drawn to the problem-solving aspect of it:

> I like puzzles. I like figuring things out. This [project] was creative because I got to design it and stuff, but it was also like a puzzle and you had to figure everything out.

This enjoyment of technical problem-solving for its own sake reflected the experience of many students I spoke to, including Maxine's disassembly of the glue gun, and will be seen in the following case as well.

In summary, like Maxine's, Jenna's path in designing the friendship necklace illustrated the constructive interaction model. She browsed the FUSE website and, from the available options, noticed the jewelry design activity. She set up the computer browser windows that would allow her to see instructional models as she worked. Like Maxine, she worked in isolation, although her goal was firmly situated in a social context: she sought to make a lasting contribution to her friend group with an object that would memorialize their friendship. Jenna had models in mind as she worked (necklaces that fit together and symbolized personal connection), but she had an unmet need: a necklace that would represent more than two friends. Her innovation took the form of a set of puzzle pieces. Like Duncan and Franklin, the effortful process of trying to reproduce and innovate led to obstacles and challenges; for Jenna, this involved learning how to resize proportionally in TinkerCAD. It also involved applied, emergent mathematical problem-solving as she responded to failure with adaptation: after printing a necklace that came out too large, she had to reduce it by 20% and enter the corresponding calculations into TinkerCAD. Once this work had been done to her satisfaction, she gave it to her friends. The trimester was over at that time, bringing the project to an end. Jenna knew to complete the portfolio and reflection to Mr. Jacobson's satisfaction, navigating the course requirements to achieve a high grade.

This case is notable also for the way in which Jenna's interest fits neatly within the first two levels of the interest framework from the early theorists (De Garmo, 1911; Dewey, 1913), with a possible hint of the third level, the development of her "spirit" or identity. Jenna's work derived from material and social foundations of interest: she liked "puzzles" and "figuring things out" as she worked on a decorative object, and the activity was motivated by a desire for recognition and memory within her friend group. Asked at the end of the trimester what she wanted to do when she grew up, Jenna responded, "I want to do something creative … interior designer, website designer" and identified the friendship necklace activity as an example of something creative.

No "I" in Team

"Ellen" and "Kyle," 7th graders, were enrolled in Eagle Lake's special education program. Tech21 was their only "mainstreamed" class, which they attended with an aide who was occasionally involved in helping or facilitating their work, though not in the project I describe here. As Ellen and Kyle reviewed their available options in Tech21, they watched several preview videos for challenges on the FUSE website. One challenge, "Solar Roller," stood out to them. Kyle was excited by the prospect of making a car that would move from the power of a flashlight, saying "let's do that one, Ellen!" Ellen agreed, and the two began their work, which extended over 12 class periods.

Assembly of the light-powered car involved a complicated organization of multiple car components, including wheels, axles, a motor, solar panels, and capacitors and wires of different sizes. The process of organizing resources was ongoing as the project increased in complexity over the course of many stages. Ellen took the lead throughout the project, with Kyle appearing pleased to take on various roles. Figure 25 shows Ellen first directing Kyle to hold a wire in place as she reaches for another component. As she realizes that they are missing the size they need, she asks Kyle to obtain it for her from a box across the room, directing him where to go. (I played a role in this interaction. I believed that Ellen had made a mistake and that the capacitor they needed was in the materials they had already obtained, and so I intervened to correct her. Ellen politely but firmly responded to me that the part was in fact in the box she had directed Kyle to obtain. Ellen was correct, and I will refer back to this incident later in this section.)

Figure 25. Discovering that they are missing a capacitor, Ellen directs Kyle to another area of the room where the part can be found.

The work to assemble and run the car continued as the FUSE challenge increased in complexity. Having completed the first level of the challenge, Ellen and Kyle began the more difficult second level, in which they had to install capacitors that would store energy from the solar panel, enabling the car to go forward after the light source was removed. Figure 26, depicting their efforts to assemble the car after Kyle had obtained the required capacitor, shows Ellen leading the joint work. She first says “I don’t understand what to do,” then locates the instructional image on the FUSE web site and exclaims “Here, this will help us, Kyle!” Carefully examining the model, she turns its visual representation of the car assembly into a verbal representation for Kyle, saying “we need to put the capacitor in the same row”. Kyle, whose role in the project had until then been limited to obtaining materials and holding components for Ellen, then takes a more assertive stance, asking “can *I* put it in the same row?” Ellen agrees and positions the breadboard so that Kyle can access it.

Figure 26. Ellen and Kyle install capacitors on their light-powered car.

Left: Ellen locates and examines a diagram showing the capacitors that need to be installed on the breadboard.
Center, right: Kyle asks if he can install the capacitors as Ellen makes sure he installs them properly.

I spoke to Ellen during a break in the work:

Peter: *Can you tell me about this challenge?*

Ellen: This is something where you figure out—you try and figure out how to do what they want you to do. Sometimes you succeed and sometimes you don't.

Peter: *How do you feel about it?*

Ellen: I'm fine with it, but sometimes it's not easy.

Peter: *What do you do when it gets hard?*

Ellen: I just keep on trying and trying to figure it out.

Peter: *Is this fun?*

Ellen: Yeah!

Peter: *What makes it fun?*

Ellen: Trying to figure out stuff even though it's hard.

Like Jenna, Ellen enjoyed the act of "figuring out." A nuance in Ellen's phrasing is significant in illustrating the difference in the way students experienced Tech21 as compared to their other classes. When she spoke of the need to "figure out how to do what they want you to do," two meanings might be associated with "what they want you to do". In science class, the students were directed to solve a problem involving their solubility tables. This was a goal established by the teacher and students were told what to do. In contrast, Ellen's "what they want you to do" meant the model that she was willingly trying to reproduce. Ellen voluntarily chose to do this work, as evidenced by her eagerness to start the activity each day and her strongly affirmative reaction to my question as to whether the activity was fun. Kyle enjoyed himself as well, drawn not just to the excitement of the technical challenge of the project but also to his collaboration with Ellen:

> Peter, we're working together! And remember, there's no 'I' in team! Like, me and Ellen *are* a team. And we're doing a good job, aren't we?

For both students, then, the material and social foundations of interest were in play. Both students enjoyed the concrete challenge, including "figuring out" the complex technical device. Kyle liked the interaction with Ellen, and she stepped expertly into the social role of coordinator and demonstrator of the activity, just as Kira will in the case presented in Chapter 4.

With the car assembled, the challenge then required Ellen and Kyle to set up a track on the floor on which to race their car. After reading instructions in the challenge that specified the first step—measuring out 120 inches—Ellen directed Kyle to find a tape measure. He found one and the two of them measured out the correct distance.

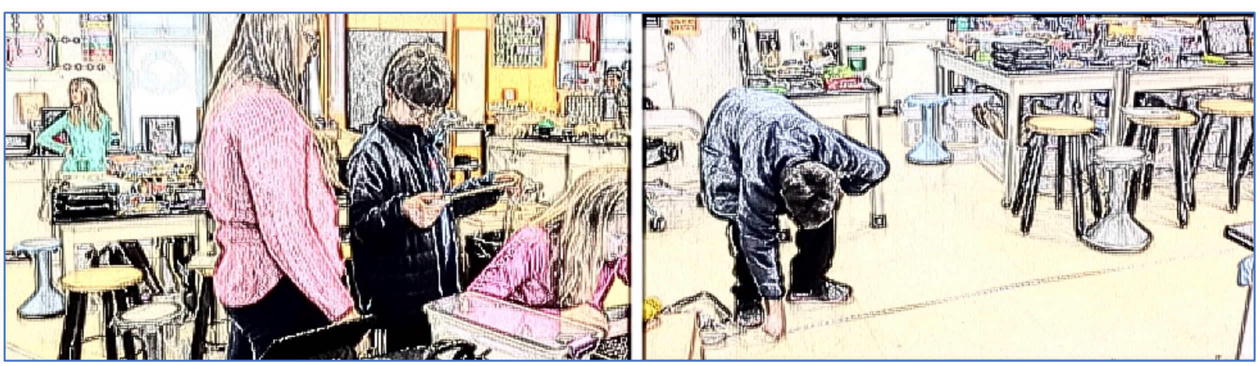

Figure 27. Kyle and Ellen measure out and set up the track.

Although Ellen took the lead on the project, Kyle was an active participant throughout, looking for ways to get involved and eagerly accepting assignments from Ellen. When it came time to test the car, Kyle created a role for himself as videographer of the project, using his iPad to record their attempts to get the car across the finish line. At my suggestion, Ellen began a tally on the whiteboard called "Tries". After each failed attempt, she marked a tally. On their 14th attempt, they were able to complete the challenge. Both Ellen and Kyle lit up with excitement, and many of their classmates cheered for them.

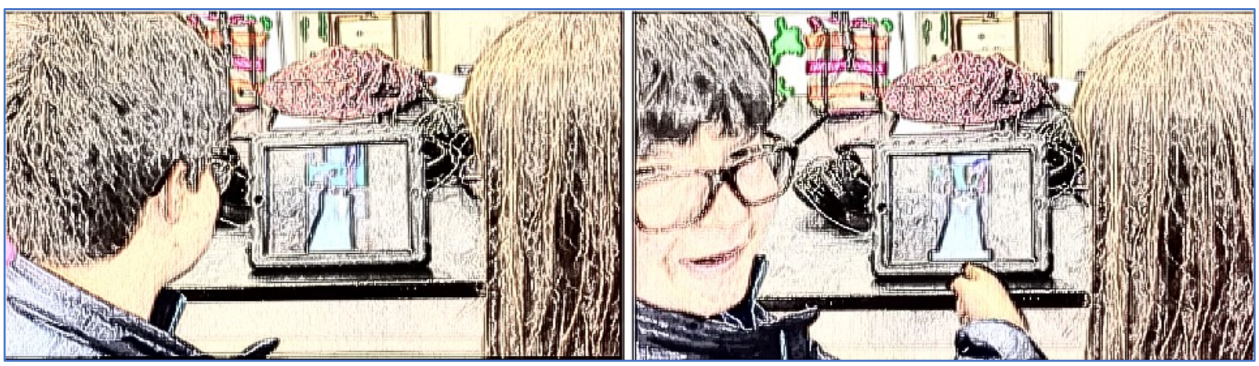

Figure 28. Kyle displays his work as videographer to the researcher and an aide, showing the recording of the successful 14th try.

Kyle watched his video of the achievement repeatedly and showed it to Mr. Jacobson, his aide, to me, and to others in the class (*see* Figure 28). The video representation of the project was a source of joy and delight to Kyle, and showing it to me and others involved a series of technical steps on its own, as Kyle had to open the correct app on his iPad, locate the correct file, and manipulate the controls. In contrast, the representation of the project that Mr. Jacobson required—the year-end "portfolio"—was significantly less successful. Creating the portfolio website, which Jenna had done easily for her friendship necklace, involved complicated steps that neither Ellen nor Kyle was able to accomplish smoothly. Another student tried to help Kyle, but he became discouraged and then intensely frustrated, banging his head on the table until he was taken outside with his aide.

McDermott (1996) described the case of Adam, in a chapter provocatively titled "The acquisition of a child by a learning disability." McDermott shows that an eight-year-old student who was classified as "learning disabled" appeared incompetent in certain contexts, such as classroom testing, but highly competent in others, such as an afterschool cooking club. Adam's "disability," in McDermott's (1996) analysis, was not a fixed, objectively recognizable trait that he carried from place to place, but a local construction dependent on his environment and the differential opportunities it afforded for him to be successful. Like Adam, Kyle was able to achieve significant success in one context (the light-powered car). He had many opportunities to take on productive roles afforded by the activity and by Ellen's skilled and friendly direction—resource manager, technician, measurement specialist, videographer. In these roles, he was happy, productive, and, by all measures, successful. Although they moved at a slower pace, Kyle and Ellen achieved exactly the same success that other students had. In contrast, when Kyle was asked to produce a "portfolio," he was faced with what appeared to him to be an arbitrary, confusing, and complicated task, and he responded by hitting his head on the table. There were two Kyles in the STEAM Lab, then: Kyle the videographer, technician and efficient collaborator, and Kyle the learning-disabled student unable to produce the school-required portfolio. Ellen's experience was more uniformly successful, although my own interaction with her was telling. Despite being sensitive to the phenomenon McDermott (1996) described, I still brought to my observations and interactions a set of beliefs about Ellen's and Kyle's capacities. In the incident described above, I assumed, incorrectly, that Ellen was incapable of identifying the correct capacitor and that she needed my assistance. Ellen withstood my "help" in this instance by confidently correcting me, but I wonder whether in other contexts people making well-intentioned efforts to guide her are similarly misjudging her capacities.

The experience of Ellen and Kyle, and that of many other students, points to a gap in the interest framework I have presented (De Garmo, 1911; Dewey, 1913), which locates the sources of interest in the survival and development of the "self." In its first level—"material" foundations of interest—that framework interpreted self-sustaining activity as originating in people's desire for food, shelter, clothing, and decoration of the body. This view adequately accounts for the extended time dedicated in the STEAM Lab to the production of decorative objects (such as Jenna's necklace) and to the many student projects involving bedrooms and houses, but does not account for what appeared to be the simple material pleasures of technical, hands-on problem-solving that so many students spoke for. Dewey had argued (1913) that as people had migrated to cities and no longer engaged in the practical occupations needed to sustain day-to-day life, young people had lost

> the close and intimate acquaintance got with nature at first hand, with real things and materials, with the actual processes of their manipulation …. In all this there was continual training of observation, of ingenuity, constructive imagination, of logical thought, and of the sense of reality acquired through first-hand contact with actualities. (8)

In the absence of such concrete material experiences, De Garmo argued, "the greatest sources of interest in the young remain almost untouched by the school" (1911: 88). These scholars could not have anticipated the remarkable array of devices that would be available to students a century later, many of which produce the "powerful effects" that Papert (1980) called for. These devices, such as the light-powered car kit that fascinated Ellen and Kyle, attracted interest and sustained attention from many students in Tech21. The material dimension of the interest framework model could be extended, in this light, beyond the "self" to include objects that are somehow interesting in their own right simply because of the technical complexity and dramatic phenomena that they make available to students.

Cecilia, This Shy Person

8th grader "Cecilia" started in Tech21 building on work she had done in her social studies class studying utopias. This work outside of the Tech21 class became the basis of her first project, a model community in Minecraft called CeciliaTopia. She discussed with Mr. Jacobson the parameters of the project, including the scale at which the community would be built relative to the other Minecraft structures being worked on by other students (*see* Figure 29)

Figure 29. Cecilia and Mr. Jacobson negotiate the boundaries and scale of her proposed utopian community, CeciliaTopia.

Mr. Jacobson asked Cecilia to sketch out a plan, which she did on her iPad before starting work on the desktop computer (*see* Figure 30). The two thus collaborated on a model that would serve as the basis around which she would organize her subsequent work. Cecilia organized her iPad next to a desktop computer, where the sketch served as a reference for her ongoing work (*see* Figure 31). Responding to Mr. Jacobson's feedback that it should be "more realistic," Cecilia included a number of practical and concrete elements that would support her community, such as a barn for livestock.

Figure 30. Cecilia's sketch of her Utopian community.

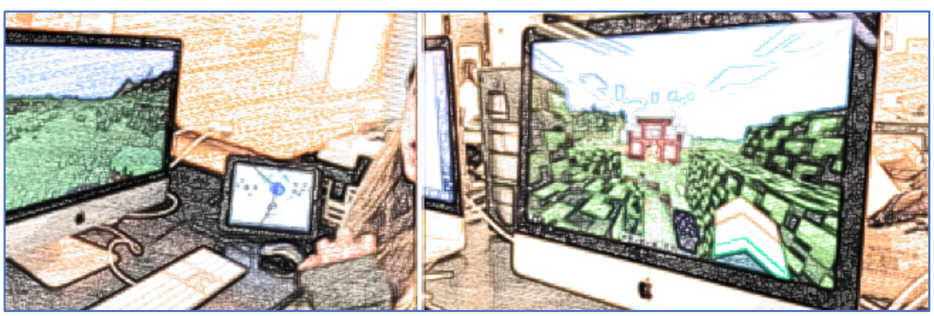

Figure 31. Ceciliatopia, a utopian farming community.

Left: Arrangement of iPad next to the main computer monitor.
Right: One section of CeciliaTopia as constructed in Minecraft.

After about 10 school days, CeciliaTopia was completed. Cecilia proudly gave me a tour, showing each component and emphasizing what she called the “realistic” elements.

Cecilia then turned to working on a series of art projects, both in a notebook and using a drawing app on her iPad. This choice originated in existing line of practice that Cecilia was pursuing outside the STEAM Lab; her notebook and iPad were already full of her works in progress. I noticed a sketch of a dragon on the iPad:

Peter: *What's that?*

Cecilia: This is just a drawing I did. *[Briefly displays the iPad to my camera, then conceals it;* see Figure 32.*]* It's nothing important. Just something I drew.

Peter: *Why is it not important?*

Cecilia: Well, I mean, it's … I don't know. I just don't like to show people my drawings. I tend to do that a lot [hide my work].

Figure 32. Cecilia briefly displays her sketch, then conceals it against her chest.

Much of the work to sketch the dragon had already been done by Cecilia outside of class, and I spoke with Cecilia to hear her account of the learning process (*see* Figure 33).

Peter: *How did you learn how to do it?*

Cecilia: I printed out a sketch of it and then I tried to copy it … well, not copy it, but I tried to do the things that they did in designing a dragon and so then I added the shading and then I went over it with the black marker here and then I had the color tool, which is different colors to help shade the thing.

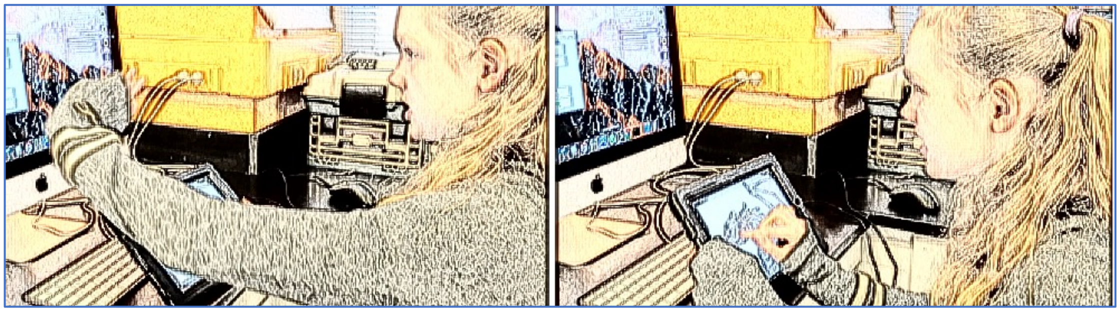

Figure 33. Cecilia re-enacts in pantomime how, at home, she printed a model of the dragon and mounted it above her computer (left) and used it as a reference as she drew (right).

A few minutes later, Cecilia began working on drawing the iris of an eye, continuing a project she had been working on at home (*see* Figure 34).

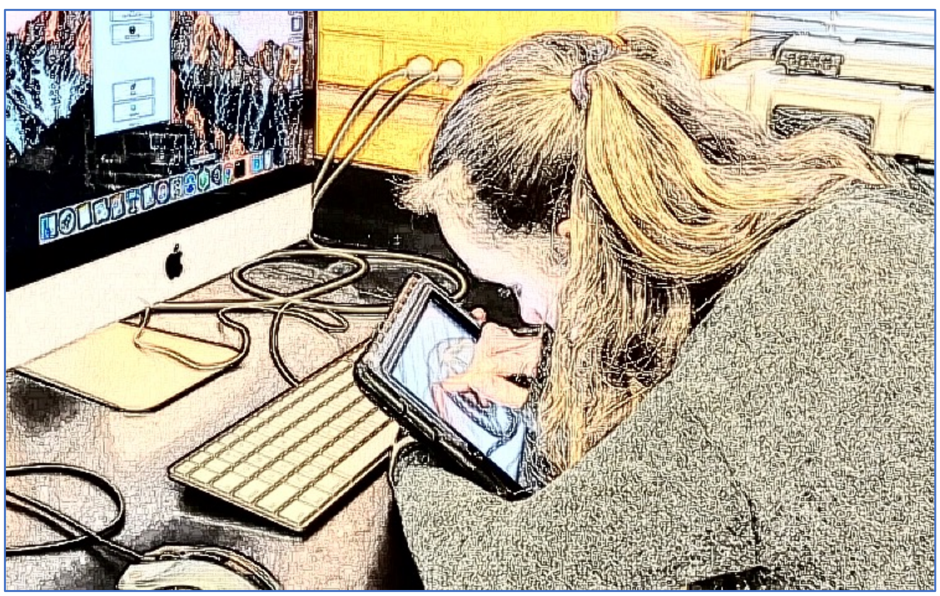

Figure 34. Cecilia's drawing of a human eye.

Peter: *Can you tell me about how you did that?*

Cecilia: Well, so, I sketched out an eye and I looked up the basic structures of an eye, the little glint and how the iris is configured, and then I sort of tried to replicate that in a drawing.

In both of these accounts, which I suggest represent clear examples of the steps in the constructive interaction model presented above, Cecilia describes an organization of resources – a sketch which she printed out and posted on the wall by her computer, and an Internet search for a picture of the human eye—that she used to create visible models for her work. She describes efforts to reproduce—she tried to "copy" the dragon and "replicate" the eye—which in the case of the dragon had led her to investigate and master the drawing app's color tool and to learn how to create shading. Later in the quarter, Cecilia described a newfound interest in mandalas, which she had seen online. She now envisioned taking a step beyond replication, making a creative innovation:

> I like to draw mandalas. I do an entire page of one. If I do a time lapse of it, it would make a really cool thing. And now I'm thinking about trying to convert that into a tattoo, a temporary tattoo. Trying to figure out how that could go on your arm. Maybe converting that design into a T-shirt or something.

Cecilia's line of practice, then, now included a series of projects (the dragon sketch, the eye sketch, the time-lapse mandala) and she was now broadening her work into other media such as body art and textiles. To this point, the line of practice centered on art-*making*, which was something she had done primarily for herself. She told me that only her mother and one friend had seen her artwork. Could Cecilia be considered a full-fledged *artist*, at this point? Identity is "double sided" (Stevens et al., 2008) in the sense that people must ultimately be recognized and identified by others as successful practitioners, a move which locates the individual within a socially situated community of practice and thus sustains and encourages the development of the identity.

This move from art-maker to socially recognized artist was problematic for Cecilia, who thought of herself as a "shy person" and was reluctant to present and share her work. Although she ostensibly tried to keep her artwork private, other students regularly noticed and commented on it ("wow, you're good!" was a representative remark), and Cecilia appeared to welcome the praise. Her initial reaction to my question about the dragon—to display, then conceal it—revealed a tension between Cecilia's production of artwork as being for herself or for sharing with others. This dynamic was further reflected in her response to a question I posed:

Peter: *Why are you doing this?*

Cecilia: Just for my own entertainment. I find it cool that I can replicate these amazing [drawings]. I just find it pretty cool that I can do that, and my friends find it really cool and I sometimes can draw stuff for them, which I find very cool.

In this response, Cecilia makes two different and contradictory points: first, that the drawings are "just for my own entertainment" (art-making as an individual practice) and that she can sometimes make drawings for her friends (art-making as a socially directed production). In another interview, I followed up on this tension.

Cecilia: I don't give my ideas [drawings] to my classmates. I'm sort of this shy person.

Peter: *What would happen?*

Cecilia: That's my fear. I'm scared people won't like it. … I'm just very shy about my work. Maybe people will judge it and think it's not good. I don't consider myself a very good artist.

Peter: *Why don't you consider yourself a very good artist?*

Cecilia: I don't know. Compared to so many good artists out there and different perspectives on things, I don't think I'm one of the top ranking ones.

Cecilia's anxiety about her own competence derived from her comparison of her own work with the examples of expert work she had seen online.[23] Cecilia described searching the Internet and coming across the work of artists she respected. These models served as exemplars not only for moment-to-moment work on particular projects, but also as resources Cecilia could use as a basis

[23] This sense of inferiority shows that models are not necessarily or always productive for learning. Exposure to examples of expert work can, for some, be demoralizing and can discourage the pursuit of a line of practice. The phenomenon of "impostor syndrome" (Clance & Imes, 1978) may be connected to seeing models of successful practice and concluding that one is not capable of executing the practice to the same standard.

for her own emerging identity as an artist. She expressed a desire to "be like" the artists she had seen on YouTube:

> I see these amazing speed drawings and I know I could never do—well, if I put my mind to the test, I bet I could do it, it would take me a long time, but *[confidently]* I bet I could do it, and that's what I want, to sort of achieve that. But compared to them right now, I'm not as skilled as them. But I want to work up to be like that. And like have those ideas and have that design…. I see so many speed paints and speed drawings that are really cool, and I don't know who they're by, but I would like to be able to draw like them some day.

In this passage, Cecilia begins with a particular material model: the speed drawings she sees on the Internet. She begins to make an assessment that she would be unable to successfully reproduce this model: "I know I could never *do* ..." before catching herself and describing a plan by which she could learn how to make the speed drawings. Even as she speaks, she discovers a possible new capacity—"I bet I *could* do it, it would take me a long time." This goal generated a comparison and an assessment of the skills she currently has and the skills she would need. In this example, working from models—making art that looked like what she had seen, doing it the way she had seen it done, and "being like that" (an artist whose work is seen by others)—shaped Cecilia's project and her broader line of practice.

Early in the trimester, Cecilia had told me that only two other people—her friend and her mother—had seen her art. By the end of the trimester, however, Cecilia had started an Instagram page for her art and was more freely sharing her work with classmates. In our concluding conversation, she reflected on her learning experience in Tech21.

> **Peter:** *What's "learning"?*
>
> **Cecilia:** There's different aspects of learning, I guess. There's learning mentally, where you're learning math and science and reading and writing in school, but there's also learning of where you're going to develop yourself into a person. Or learning different ways around life. And learning how to solve problems and overcome an obstacle. So there can be two different sides of learning.

For Cecilia, this second side of learning—overcoming the obstacle of her shyness, developing into an artist—had developed in the STEAM Lab. She concluded:

> I'm really happy I took this class because you get to experiment by yourself and you get to create your own rules and you get to create whatever you want and have meaning to create that. And I feel like not many classes have this freedom and this crazy design of a classroom.

Conclusion

In this chapter, I sought to describe and theorize learning in a structured-choice environment. I presented a series of perspectives on learning from educational and learning sciences literature, including learning as internal cognitive reorganization, knowledge in practice, increasingly consequential social participation, change in identity, navigation of institutional requirements, and personal development. I then turned to a description and analysis of data from the STEAM Lab, from which I produced a composite data narrative. I theorized structured-choice learning as a process of *constructive interaction.* Although grounded in observation of a structured-choice environment, I proposed that the constructive interaction framework may be a resource for the design of learning environments more broadly, and may have implications for the analysis of other learning environments such as traditional classrooms. I then presented ethnographic cases of student learning, showing their connection to the constructive interaction model and their relationship to prior literature.

CHAPTER 4

Kira & the Spinners: Logics in Conflict in the STEAM Lab

Abstract

In this chapter, I report a case drawn from 6 months of ethnographic and interview research in the Tech21 elective at Eagle Lake Junior High. Students in Tech21 produced complex, creative work such as e-textiles, architectural models, and 3D designs. Free to choose what to work on and for how long, and to work individually or in groups, they organized themselves into productive arrangements for learning. The Tech21 teacher struggled, however, to apply Eagle Lake's grading practices within this humanistic learning environment. I tell the story of Kira, a 7th grader who learned to design and 3D print an original fidget spinner, then guided classmates as they learned to produce their own. Kira's story came to a surprising and sad end, as she failed to produce the "evidence of learning" that Eagle Lake required. The case has theoretical importance, I argue, for initiatives to bring humanistic learning environments into schools.

Introduction

This chapter explores what can go wrong as logics come into conflict: when humanistic ideas about teaching and learning in schools intersect with scientific models of assessing and grading student work. I document the tensions and systemic contradictions (Engestrom, 2001) faced by schools and districts as they begin to develop contexts for learning organized along humanistic principles (Kilpatrick, 1918, 1925). Education leaders increasingly speak of the importance of "21st century skills" such as collaboration, creativity, and persistence through challenge (National Research Council, 2013). This rhetoric has been operationalized in settings such as Eagle Lake through the construction of "makerspaces" (Halverson & Sheridan, 2014) or "STEAM" learning environments, in which 21st century skills are thought to develop as students participate in hands-on activities involving applied science, technology, engineering, arts, and mathematics. When this activity is combined with the principle of student choice, significant student engagement and interest development can occur (Ramey & Stevens, 2018; Stevens et al., 2016; Stevens et al., 2018; Ramey, 2017; Penney, 2016), as described in the ethnographic narratives presented in Chapter 3. But how can a teacher recognize, assess, and grade this activity? In the absence of tests and other forms of formal quantitative assessment, what constitutes "evidence of learning"?

I report a case (Ragin & Becker, 1992) of this dilemma, the story of a 7th grader named Kira. Her story is drawn from the ethnographic and interview research I conducted in the Tech21 elective, described in previous chapters.[24] As documented in Chapters 2 and 3, Eagle Lake constructed a "STEAM Lab" and engaged Mr. Jacobson to teach a class that offered 7th and 8th graders access to a diverse collection of technology-focused activities or "challenges",

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[24] This chapter is adapted from a manuscript in preparation developed by Meyerhoff & Stevens.

including robotics, circuitry, simulations, game design, and 3D design and printing. Students were free to choose what to work on and for how long, and could work individually or in groups. The environment was strongly supported by school and district leaders at Eagle Lake, who spoke approvingly of student "voice and choice" and valued what they called "project-based," "hands-on," and "experiential" learning. The superintendent believed that 21st century skills were "the hardest ones that kids can learn right now," and Tech21 was one of many initiatives the leadership team had organized throughout the district to develop these skills in Eagle Lake's students. Mr. Jacobson had volunteered to teach the class, eager to provide students with freedom and choice.

During my observations in 6 Tech21 classes, as described in Chapter 3, I found substantial and sustained student engagement with complex, ambitious technical projects. Mr. Jacobson stood in the background or informally facilitated as students persisted through significant challenge to complete elaborate constructions, from digital artifacts such as 3D designs and architectural plans to concrete objects such as e-textiles and solar-powered cars. Students provided modeling, instruction, guidance, and coaching for each other. But I also found a dilemma (Cuban, 2001), as Mr. Jacobson faced the problem of applying Eagle Lake's conventional grading practices within the humanistic learning environment of Tech21. Prior research has explored the tensions of assessment in project-based learning activity. Stevens (2000a) documents the story of a middle-school student he calls Ted, who collaborates with a team on an architectural design project that includes complex mathematical sense-making and emergent problem-solving, only to encounter problems as the teacher sought a school-authorized artifact (a worksheet) to grade. The "institutional invisibility" (Stevens, 2000a: 134) of project-based learning is present in both Ted's and Kira's stories. Mr. Jacobson struggled, like Ted's teacher, to find a language in which to represent what both he and the superintendent called Kira's "evidence of learning."

These two dimensions of the Tech21 experience—the dynamic, collaborative engagement in freely chosen projects and the need to assign a grade—came into conflict in the case I present here. Over the 11-week term, I traced Kira's emerging line of practice as a 3D designer. Kira taught herself to make a fidget spinner, then expertly guided two classmates as they learned to construct their own spinners. Troubled socially and academically at Eagle Lake, Kira found a home in Tech21, calling it a "dream come true" and coming in on her lunch period to do extra work on her projects. Mr. Jacobson, an experienced facilitator who believed strongly in the Tech21 vision, watched with pride as she acquired a complex skill, built a working spinner, taught her peers, and earned their respect. In this chapter, I explore what went wrong for Kira, Mr. Jacobson, and Eagle Lake as they negotiated the challenging terrain of 21st century learning. What counted as "evidence of learning" in Tech21? I first provide "endogenous" evidence (Stevens, 2010) of learning, drawn from videoethnography of Kira and her collaborators. I then document Mr. Jacobson's efforts to locate and grade "exogenous" evidence of learning, in the form of student reflections and portfolio. The end of Kira's story is surprising and perhaps saddening, but it has, I will argue, theoretical importance for exploring the dilemmas that emerge when humanistic and scientific logics collide in school.

Research context

As described in Chapter 2, Eagle Lake prided itself on its longstanding identity as a "progressive" public school. Administrators explicitly saw themselves as inheritors of the district's rich history, and interpreted Tech21 and similar programs offered in the district as reflective of progressive practices, which they identified variously as "project-based learning", "experiential learning," "hands-on learning", "STEAM," and "learning by doing". They also associated the progressive label with "student voice and choice" and with student "interest". They constructed the STEAM Lab in accordance with this vision, filling it with an abundance of complex devices and tools that they believed students would find interesting and enjoy working with. The teacher, Mr. Jacobson, established an activity structure in which students could decide what to work on and how to organize themselves.

The experiential, hands-on learning experience available to students in Tech21, including its choice-based component, was not new to the students at Eagle Lake. Like young people in many middle- and upper-class American communities, students were able to pursue their interests in afterschool programs, summer camps, and other out-of-school settings (Sefton-Green, 2012). In these environments, facilitators, mentors and instructors can mostly avoid the problem of grading. Eagle Lake, in contrast, faced the challenge of being expected, as the superintendent described, "to clearly define evidence of student learning" and to assign grades to all students at regular intervals. Mr. Jacobson was given little guidance from administrators in how to adapt the school's assessment and grading practices to the "21st century" learning environment in Tech21. This setting, then, constituted an auspicious context in which to look for the evidence that district leaders sought and to examine the ways in which one teacher struggled to find the evidence of learning he needed to produce a grade.

Methods

The research methods for this study were described in Chapters 2 and 3. Stevens (2010) calls for analysis of learning "from within": a "documentation of learning as it is co-constructed in and across events between people, and between people and things, in everyday life" (83). From this *endogenous* perspective, evidence of learning emerges not through analysis of external instrumentation (such as pre- and post- scores), but through close study of the ways in which members themselves organize, sustain, and interpret interactions to be about learning and its evidence. To achieve this "endogenous" view of Tech21, I conducted approximately 150 hours of observation and interaction with participants and their facilitator at Eagle Lake between November 2016 and June 2017, and continued the observations from September to November 2017. I interviewed Mr. Jacobson during and after class each day, and conducted structured interviews with 7 school and district leaders. 86 students and their parents provided consent to participate in the study. I conducted "cognitive ethnography" (Hutchins, 2003), attending in particular to the ways in which the material environment—the objects, devices, and tools that form the basis of the Tech21 experience for participants—acted to organize social and cognitive activity. I reviewed 51 hours of videorecordings, drawing on a method for viewing and re-viewing video recommended by Erickson (2006) and on the techniques of interaction analysis (Jordan & Henderson, 1995; Goodwin & Heritage, 1990; Stevens & Hall, 1998; Hall & Stevens, 2016).

The case of Kira sampled for presentation here is representative of the creative, collaborative work that characterized the student experience in Tech21 and also brings the teacher, Mr. Jacobson, into the foreground. Previous research on FUSE (e.g., Champion et al., 2016; Penney, 2016) has documented a culture of help-giving, in which students—rather than the teacher—emerge as "relative experts" with respect to particular practices and become a resource for others. This culture developed in all 6 Tech21 classes at Eagle Lake, and Kira's guidance of her friends represents a vivid example of the phenomenon. However, Mr. Jacobson came to figure prominently in Kira's story, and her case presented him with a difficult problem of professional practice that we discussed at length. By sampling this case for analysis, I hope to shed light on the dilemmas that may emerge when a teacher tries to reconcile humanistic practices with school-based assessments (Stevens, 2000a).

Kira & Mr. Jacobson

Mr. Jacobson organized an introductory week of "design thinking" (Brown, 2009) lectures and activities, after which students in Tech21 were allowed to choose from 32 FUSE "challenges" or from activities in the STEAM Lab, including Minecraft, a rocket-design simulation called Kerbal Space Program (KSP), and programmable devices such as the Sphero robot. They were permitted to work independently or in groups. Students were assigned to write a brief "weekend update" or reflection on Fridays, although many did not. Mr. Jacobson kept track of the weekly reflections using Google Classroom, and also made use of a learning management system called ClassDojo, where he recorded student behaviors such as being "on task" or showing "enthusiasm". He would walk through the room at least once each day, chatting informally with students and occasionally offering a substantive suggestion, but otherwise did not play a central role. Having organized the various activities that would be on offer, Mr. Jacobson was content to allow students to proceed on their own. When students came to him for help, he sometimes provided it but more commonly advised them to seek assistance from others or to work it out on their own.

Making the spinner

7th grader Kira started by making jewelry and a keychain, working on FUSE challenges that use TinkerCAD, a 3D design application. In a pattern commonly observed in FUSE, Kira decided to make a "productive deviation" (Hilppö et al., 2016) away from the keychain activity and towards an idea of her own: a fidget spinner. By the spring of 2017, spinners had become a national craze; many Eagle Lake students had purchased one. Kira relied on the video tutorials from FUSE to give her models by which she could learn TinkerCAD. Although she did not explicitly connect her activities with the "design thinking" approach that Mr. Jacobson had taught, Kira went through several cycles of ideation, prototyping, and refinement as she produced her first iterations of the spinner. Once immersed in the project, she started coming in on her lunch period to work on it.

Creating a spinner that "looked cool"—Kira's stated design goal—became an intensely engaging activity for her. She faced important challenges along the way. As she approached completion of the object, she realized she had made an important mistake at the outset; she had failed to correctly measure a critical part. Fidget spinners use a central metal bearing that must fit tightly into the plastic frame. The width of the hole in the digital design must be about 0.1mm smaller than the width of the bearings. Kira had correctly used digital calipers to measure a bearing, but the bearing she measured was smaller than the one she ended up using. As a result, she produced a frame, but the bearing did not fit. She located a metal file and began to file down the edges of the central hole. When class ended, she quietly took the file from the studio, violating a rule about taking tools out of the room. She proceeded on her spinner during English class, prompting a tense call from the English teacher to Mr. Jacobson and causing him to deliver her a stern reprimand. These efforts, nevertheless, provide strong evidence of Kira's agency and interest in the project. In the end, Kira completed a distinctive, original artifact (*see* Figure 35) that she called "a really cool fidget spinner." She then moved on to another interest—jewelry—and used TinkerCAD to design herself a bracelet.

Teaching Joe and Franklin

Kira’s spinner was noticed and examined by many of the other students, including two other 7th graders, Joe and Franklin. Their interest extended beyond a simple expression of curiosity, as they actively enlisted Kira’s help in making their own spinners. In this sequence, Joe recruits an initially-reluctant Kira as an instructor for himself and Franklin:

Figure 35. Kira's spinner (above) and Joe's inspection (below.)

1	*J*	Kira, are you making spinners?
2	*K*	Yeah. Well, I, I made one. I’m not going to make more. I just made one.
3	*J*	Can I see it? Does it work? (Picks up and tries out the spinner)
4	K	Yeah.
5	*J*	Is it hard?
6	K	Not really. ***[Turning to face Joe]***
7	*J*	What program did you use?
8	*K*	TinkerCAD. I kind of cheated a little bit, because I took an original, like a regular boring one like Franklin’s, and then I made it like interesting.
9	*J*	All right. Because I was thinking of doing that when I was done. So I just wanted to know.
10	*F*	Yeah, me too!
11	*J*	Yeah, like Franklin and I might do it together.
12	***K***	**Make sure you measure the bearings that you’re gonna use, because I measured different bearings than the ones I used.**

Kira’s movement toward Joe at turn 6, followed by her provision of direct advice (based on her own experience) at turn 12, marked the beginning of her work with Joe and Franklin as an instructor. Over the next 3 weeks, Kira cumulatively provided at least 60 minutes of face-to-face, intensive modeling, instruction, and guidance to Joe and Franklin. During this process, Kira’s newly developed expertise was clearly in evidence and was explicitly recognized and respected by Joe and Franklin. She used the craft knowledge she had acquired to guide her classmates around a possible source of error: measuring the wrong bearing. Joe and Franklin watched carefully as she entered parameters into the TinkerCAD software and adjusted the 3D "views" of the objects being designed. They valued Kira's expertise and actively sought her assessment of their work, even attending closely to the body language conveyed during her reactions to the work they showed her:

1 Franklin	*[Turning his screen to Kira and Joe, who examine Franklin's spinner]* Does that look cool? Is that how you do it?
2 Kira	*[Shrugging; pursing lips; shaking her head]* Sure.
3 Franklin	No. I take that as a no.
4 Kira	*[Turning back to her measurement work with Joe]* No, it's whatever you want it to look like.

Kira's emerging identity as an instructor to Joe and Franklin resulted in many "teacherly" moments, as the three students mutually entered into reciprocal positions as teacher and learners, and sustained those positions through extended interactions (Stevens, 2010). These interactions included "embodied movements" (Vossoughi et al., 2019) in which Kira's movements created productive opportunities for Joe and Franklin to watch and participate in the actions she sought to model. At one point, she became engrossed in solving a particular problem with the TinkerCAD interface, leaving Joe and Franklin with nothing to do. One of them elbowed the other and they began a good-natured slap-fight. After a time, Joe said to Franklin: "we need to pay attention" and they returned their focus to Kira, an incident that confirmed their identification of Kira as their teacher. This "teacher" identity, including its "double sided" reciprocal nature (Stevens et al., 2008), culminated in a final exchange with Franklin. He had proceeded more slowly than Joe on his project, and continued to go to Kira with questions. Kira ultimately rebuffed his last request for assistance, concluding that he was now able to proceed independently: "I've helped you so much … you now know how to use TinkerCAD … that's all you need to know how to figure it out yourself." Kira here had made a judgment that it was time for Franklin to go at it independently, and somewhat sharply directed him to do so. Franklin and Joe each ultimately printed their own spinners; Joe proudly displayed his to a researcher and announced a plan to extend Kira's design by printing bearing caps to make the spinner easier to hold.

Teaching Kira

With the exception of the first week's activity, in which Mr. Jacobson gave a lecture from slides about "design thinking," he never provided direct instruction to students except when asked for assistance. Kira relied on the instructional text and videos in FUSE, as well as trial and error, to learn how to make the spinner. Mr. Jacobson did, however, circulate in the room talking with each student or group of students as they worked on their project. As described in Chapter 3, Mr. Jacobson typically provided informal feedback on the artifacts students produced and displayed for him, often counseling them to make the objects more realistic and to consider the needs of potential users. A former basketball coach, Mr. Jacobson was inclined to try to motivate and encourage students.

Mr. Jacobson's interactions with Kira reflected this coaching or facilitation model, rather one of teaching. When she took the metal file out of class, breaking a class rule, he spoke with her gently rather than out of anger. He expressed disappointment that she had lied to him about it, but did not move to punish her. I noticed that after their exchange, she spent extra time cleaning up the classroom and tried to make sure he noticed. His position as coach or facilitator, rather than judge, opened space for Kira to feel that she could approach him with questions. After she had completed her spinner, Kira asked for Mr. Jacobson's suggestion on what she could do next. They talked about possible options, with Mr. Jacobson asking what Kira felt strongly about in the world. Kira expressed concern about the problem of homelessness, and the two discussed things she might do to address those concerns:

Mr. Jacobson	It doesn't have to be a big grand idea. You can start small. Is there something that can maybe help with that?
Kira	I just don't know where to start. That's the problem. Literally for everything I do, I always need some place to start.

Two ideas in this exchange are significant. First, Mr. Jacobson's counsel to "start small," while offhand and conversational, will return in the next section as Kira reflects on her experience in the STEAM Lab. Second, Kira points out an element of what some would call her "learning style": she believes that she needs specific step-by-step instruction. This guidance as to Kira's need for concrete direction had been communicated in writing by support staff at Eagle Lake to Mr. Jacobson. To this point in my observations, this need for step-by-step instruction had not been apparent to me. Kira had mentioned that the instructional videos in FUSE had "really, really helped me," but many other students had also relied on the videos. Kira's need for guidance on "where to start" will be discussed in the section on assessment that appears below.

Kira's Learning as Development of her "Spirit" or "Identity"

Reflecting at the end of the trimester on her experience in Tech21, Kira spoke with great enthusiasm about what she had learned. She believed she had overcome obstacles to make something that she liked and had discovered capacities she didn't know she had:

> This isn't easy, this is very challenging. It tests your limits. … Last year, I'd be like ... to make my own fidget spinner or make my own toy, like how would you ever *do* that? That seems *impossible*. I'm just a kid! ... I know this sounds like super cheesy, but it's like a dream come true … It's unimaginable that I can do this kind of stuff. I never thought I'd be doing that.

Drawing on Holland et al.'s (2001) definition of "identity" as "the imaginings of self in worlds of action … [which are] important bases from which people create new activities, new worlds, and new ways of being" (5), we can see that Kira has discovered something previously "unimaginable": she has the capacity to design and fabricate a toy. This is a "dream come true" for her, and this new capacity is connected to a challenge that "tests your limits". She now has a new sense of what is possible, even for someone who is "just a kid."

The experience was memorable for Kira. 6 months later, I spoke to her about her time in Tech 21. She remembered the work vividly. Her response to an open-ended question showed that she had internalized Mr. Jacobson's counsel to "start small," using this idea and the fidget spinner itself to describe a newfound sense of agency that she attributed to the class:

Peter: *Let's say someone heard this story and they saw your spinner and saw all the work you did and the way you taught the boys. What would you want them to know about your experience?*

Kira: People are always doing these big projects where they are starting a company or something, and they're saying, "It's really not that hard. Just start small and you just have to work for it." For me, I was always like, "yeah, right." It's just so hard, how do you get those resources and stuff?

I think it really does start small. I was just making a small fidget spinner, but if there was something really bothering me I could start thinking of a way to fix it. I could start making small things.

Kira's reflection shows that she has understood Mr. Jacobson's imagery of starting small and has connected it to her own experience: "it really does start small" and she could "start making small things" if there was a problem in the world that she wanted to solve. In Vygotskian terms, "starting small" has moved from its origins as an interpsychological concept that emerged through interaction with Mr. Jacobson into an intrapsychological concept that Kira draws on to communicate this new sense of agency (Vygotsky, 1934/1978). A similar move occurred with the material object of the spinner. As she continued her response, she described a process of working with other people to actualize her ideas, and extended the metaphor of the fidget spinner:

> Then someone like Mr. Jacobson knows how to build it up and make it bigger or make into a real project. Making it big and into an actual thing. It's not that hard. I mean, it *is* very, very hard, but, it's also not. It's simple, like with the fidget spinner, it's just a bunch of shapes. *[Confidently; gesturing with her finger to draw a fidget spinner in the air]* You just take some of these shapes and make other ones into their own shapes and it connects them to become one big thing. It's a bunch of little parts, like little shapes and then you make it into one thing. You can really do that with anything.

In these comments, Kira uses the fidget spinner as a metaphor to describe the kind of learning that Eagle Lake and Mr. Jacobson wanted her to achieve. Creative endeavors, she believes, involve connecting small components into a larger whole, a capability she now believes she has. "I was just making a small fidget spinner," she reflected, "but if there was something really bothering me I could start thinking of a way to fix it." Kira had developed a clear sense of agency along with her new, developing line of practice as a designer. The spinner project taught Kira that complex and ambitious problem-solving is a step-by-step process. She continued:

> I think it kind of showed me that I can actually do these cool things as long as I have the resources. So next year at [high school] I'm not going to have this awesome STEAM Lab. I don't know what they have there, but if there was something I wanted to do I could always, if there was something that I could continue on, I could continue on with that. I could 3D print stuff there, I could do other stuff there. There are people that could help me with that.

Kira had achieved not only a personal conviction about her own agency and an emerging identity as a designer, but also had earned recognition by her peers of her expertise, an essential component of this new identity (Holland et al., 2001; Stevens et al., 2008). In the next section, I turn to the way in which this achievement was recognized, not by her peers, but by the assessment system that Eagle Lake had installed in the STEAM Lab.

Assessing Kira

I turn now to a participant who up to this point has been in the background of the story: Mr. Jacobson. In project-based environments like Tech21, teacher-facilitators circulate among students and often miss much of the activity going on somewhere in the room (Stevens, 2000a). In this case, however, Mr. Jacobson was fully aware of the productive work Kira had done to resolve problems and overcome mistakes to produce her spinner. He valued her work and saw it as a vivid example of the "21st century skills" that he spoke of repeatedly:

> She's interested in [the project] and she's excelling at it and she's collaborating and teaching others ... that's the kind of environment that I want to see here and the kind of collaboration and the kind of learning that I want to have going on.

In other words, Mr. Jacobson had good evidence of a form of learning that he valued. At this point, however, Kira's story took a surprising turn that points to a critical dilemma faced by schools implementing humanistic learning environments. The question of the *institutional visibility* (Stevens, 2000a) of this learning now presented itself. Stevens (2000a) uses "institution" in his study to mean the school itself, but I add a second meaning to resonate with the theoretical framing of institutional logics described in chapter 2. How was Kira's learning made visible to Eagle Lake's assessment rubrics and learning management software? And how was it made visible within the scientific essentialist and humanistic logics that, I have shown, were being contested in the institutional environment of the STEAM Lab?

Mr. Jacobson, mindful of a phrase he had heard many times from the district's director of technology, insisted that students "document, document, document" their work. At the beginning of the quarter, he determined he would grade performance in Tech21 through a combination of regular "weekend updates" (short essays, due each Friday, in which students would communicate their progress and "reflect" on their work) and a year-end "portfolio" featuring pictures and descriptions of their projects. Two-thirds of the grade would be based on the weekly reflections and the year-end portfolio, with the remaining one-third coming from "participation" (as Mr. Jacobson explained it, "how you were in class"). Many students had neglected to produce the weekly reflections that Mr. Jacobson had assigned. Using his Google Classroom tool, he kept track of who had and had not done the reflections. This tool represented a mobilization of the scientific essentialist logic: once Google Classroom had been authorized as a school-wide tool for teachers, its ready-made grading slots (normally used to enter grades on quizzes, papers, and tests) established a path through which Eagle Lake's programmed assessment regime would enter Tech21. As the end of the year approached, he started to consistently remind the class to get their reflections done, making verbal announcements to the whole class and posting messages on Google Classroom that the reflections and portfolio were coming due.

It is not clear from the data whether Mr. Jacobson ever explicitly told Kira, in a one-on-one conversation, that the fact that she had not turned in the reflections would have a severe consequence for her grade. Mr. Jacobson had a document from an administrator advising Kira's teachers to give her concrete instructions, and it is possible that what seemed obvious to Mr. Jacobson during his repeated announcements to the class—that failure to turn in the reflections meant a major grade penalty—was not a direction that Kira completely understood. She would later reflect that she wished Mr. Jacobson had prohibited her from doing anything other than the reflections and portfolio during the last week of school—that is, given her step-by-step instructions and shown her where to start. Most students did understand, however. Jenna, Maxine, and the other students turned in their work on time. Cecilia told me that she scrambled to write and turn in her reflections in at the end of the quarter. All of these students managed to "navigate" the institutional requirement of turning in all of the reflections and the portfolio, even if their work was rushed and cursory. Kira never did, instead continuing to work on her projects and to teach her classmates who had expressed interest in her creative work.

Mr. Jacobson gave Kira a D in Tech21. With the weekly reflections and the portfolio each constituting one-third of her grade ("participation," for which Kira received full credit, was the other one-third), Kira should have received an F, but Mr. Jacobson consulted with the principal and her academic advisor and raised the grade to a D. (Mr. Jacobson explained this change by saying he had made it "because I know that learning was there.")

The D affected Kira personally. Mr. Jacobson recounted his conversation with Kira at the end of the year: "I asked her, 'What do you think your grade is?' She was like, 'Yeah, I know I didn't do anything.'" According to Mr. Jacobson, Kira cried when he told her she had received a D, anxious about the consequences she believed she would face at home. Combined with Kira's weak performance in her other classes, the D also meant that she would be required to take a guided-study class the following trimester, which would make it impossible for her to be in Tech21 again, a context that had meant so much to her. Through her tears, she assured Mr. Jacobson that she would be in the STEAM Lab on her lunch period.

Administrators reflect on the grade. A few months after the end of the trimester, I presented an anonymized written summary of Kira's case to two assistant superintendents and to the principal of an elementary school in the district and discussed the case with them. Mr. Randall shared his view:

> I have some empathy for both the teacher and the student. In particular, the student. I know there's a lot of weird things that happen within grading. Kids get a zero here and a zero there and it doesn't adequately reflect their learning. A lot of times people get assigned grades for things that are not important or not nearly as important. The key is the learning that goes on there. … A lot of teachers are just like, it's basically check a number in a box. That stuff is maddening. And I often had those times [as a teacher, when] I would go through my grade book and I'd be giving grades at the end of semester and I'd be like, "This kid got a C, and this one got an A. Man, that doesn't just sit right with me." So I do have some empathy there.

Mr. Randall's "empathy for both the teacher and the student" reflects his recognition of both sides of the dilemma. He understands Mr. Jacobson's perceived need to enforce the grading policy, showing the hold of the scientific logic within the environment. But he speaks also for the humanistic logic: the grade "doesn't adequately reflect their learning," sometimes reflecting "things that are not important." Dr. O'Bryan expressed a stronger opinion:

> I think, honestly, this is a failure of the system. … We should be much more fluid in our capacity to—if this were a study skills class, and you needed to learn how to learn and you need to be able to document how learning happens, I'd say "Yeah, it's a D, because she didn't develop her study skills." But turning in the reflections, that component of it really had very little to do with her capacity to understand what was being taught. Did she get this information? Was she excited about it? Was she able to teach others? Was she able to understand conceptually all the different components?
>
> I would agree that, having witnessed her teaching others and having her demonstrated the creating of it, maybe it's the job of the teacher to say, "We usually document this way, but I'm going to need you to tape record you telling me how you did this." I think we fail as teachers when we have a square peg round hole and we have a box and the checklist. And I think that's, to me, that's a failure of the system. Not to be able to acknowledge that someone has succeeded at something. And the only reason she didn't succeed is because of the box an adult imposed on her.

What Dr. O'Bryan called a "failure of the system" reflected a collision between the two logics. Like Mr. Randall, Dr. O'Bryan describes a "box" that must be checked: the rubric items, instantiating the scientific logic, that enter the environment and guide the teacher's assessment practice. The grading rubric created institutional invisibility around Kira's success, making visible only her failure to turn in the written reflections. One notable aspect of Dr. O'Bryan's account is that, as a senior administrator within the district, he states that he would have been open to an alternate form of reflection (an audio recording, similar to the one Kira gave to me). Had the Google Classroom grading rubric been set up with a space in which Mr. Jacobson could enter grades for either a written or spoken reflection, perhaps the outcome for Kira would have been different.

I shared with the administrators a comment that Mr. Jacobson had made to me in connection with this case and Kira's failure to communicate her work through the assigned reflection and portfolio. If Kira had been an architect, Mr. Jacobson proposed, she would be judged not only by her actual work, but also by her ability to meet with a client and present it. Accordingly, the written reflection and year-end portfolio represented an authentic test of the work of a creative professional. Dr. O'Bryan acknowledged the point, but noted that Tech21 was not the only class where Kira could develop this skill:

> Eddie is not [responsible for] teaching her how to become a full-fledged professional in the workplace. He's teaching one aspect of her journey as a learner, and to me he's successfully engaged her. She 'never dreamed' she could do this, she became really excited about it. He succeeded in capturing that. There are other components of our educational journey that will teach you public speaking. There's English class, teaching her how to write an essay. There's all these different things and they all merge to create that composite of a person that can walk into a meeting and articulate their ideas around this. To me, his goal was to get her excited, capable, and producing and she did. I don't think it is his job to produce someone who can do everything. That's an adult-imposed model.

When Dr. O'Bryan says that he interprets the teaching goal as "to get her excited, capable, and producing," he speaks for the humanistic logic. Mrs. Carman, the principal at an elementary school in the district, wondered about what purpose had been served by the D: "[Do we think that] by giving her this grade, all of a sudden everything's going to make sense for her?" Here, she questions the function of the letter grade, noting with sarcasm that it does not serve a formative purpose in helping her to grow.

Kira reflects on the grade. When Kira and I spoke 6 months after the end of the trimester, I began by asking her to reflect on school as a whole, then shifted into a conversation about the D. Kira emphasized the freedom of choice in the STEAM Lab as being central to her experience:

> **Peter:** *What's the best thing about school, what's the worst thing about school?*
>
> **Kira:** So the best thing about school is, I would say it's the freedom in the STEAM Lab. We don't have that much freedom right now [in the rest of school], but I'm gonna get a lot more freedom when I go to [high school] next year. I like having that amount of freedom, especially when we're in the STEAM lab because you can just do whatever you want. You can choose what you want to do, what you want to learn about, what you want to make, what you want to do ... and that's the difference.

I then turned the subject to the D:

> **Peter:** *Is it OK if I ask you about your grade in Tech21?*

Kira: Sure.

Peter: *What happened with your grade?*

Kira: It was really bad because I wasn't turning in my, whatever it was called, weekly checkup. And so it turned out really bad, because I wasn't really doing that. Even though I was doing really well in the class, I just wasn't doing well with the grade because I wasn't checking in with the stuff.

Kira's understanding of what had occurred matched what I had observed during the fieldwork. She had been focused on (or "distracted" by) her work with the spinner and had ignored Mr. Jacobson's entreaties to do the reflection:

Peter: *How did you feel about the grade?*

Kira: It was kind of disappointing. I was mad at myself. I was like, darn I should have, I really should have turned it in. I was just too, like, <u>distracted</u>. I was like, no, I just want to keep working on [the spinner]. I don't want to waste my time making the weekly sign-in or check in or whatever. I was just like, I don't want to <u>do</u> that.

Peter: *Why did Mr. Jacobson give you a D?*

Kira: Although I was doing a good job in the class, that's what he said, it's that I wasn't putting in the second part where I had to reflect on it. The reflecting was kind of a big part of it. I guess, like, when I was helping [the boys], I guess <u>that</u> was kind of a reflection for me. I didn't actually do the reflection that was assigned.

Again, Kira's interpretation here aligned with a conclusion I had formed during observation: her work in the role of teacher constituted a kind of reflection. She had taken account of her earlier error in mismeasuring the size of the hole needed for the spinner—a mistake which had led to her taking a tool and lying to Mr. Jacobson—and turned it into advice which she gave to Joe.

Kira also made a series of proposals as to how the grading system might be changed:

Peter: *If you could change the grading system, how would you change it?*

Kira: You could just sort of submit pictures or show videos of your thing, like what it looks like now, so while you're working on it you can see the progress it kind of made.

Also, it should be based on how much dedication and stuff you are putting into it. There were some people who were like, their project was like Minecraft. Really [Jake and Amanda] were just playing around on Minecraft. They weren't

> actually doing it. Other people, like Maxine, she was making a cardboard chair. That was really cool and she was working so hard on that. I think the grades should be for people who are working really hard on their projects and [the teacher should] observe who really is working really hard and who is not.
>
> [Also,] on the last two or three days of Tech21, we were supposed to turn in all of our photos or something or all of our videos of our project [as a portfolio]. I think that the problem was that [the activities were] still open for us to still make stuff. I think that was the biggest problem for me. I was still available to keep working on something or do something. That's kind of why I, one of the reasons why, I didn't do [the portfolio]. If [the activities] weren't available, if we could only do that [portfolio] work, then I think that would have really helped.
>
> Or, say there was a [printed] sheet [for the reflection]. I think it was a little bit too much when it's all on the computer, so take that out. If we could just [see] all of the photos and videos and then on a sheet look at them and then on the sheet write or answer questions about what we did and overcoming the challenges.

One strand of Kira's proposals reflects the collision between the two logics: Kira questions the relative priority given to the written reflection, compared to the hard work and creativity displayed by some students. However, her advice is more practical and grounded in her own need for knowing "where to start" and working step-by-step. She calls for a specific time set aside in class in which students could only work on their reflections and portfolio, as well as a reflection worksheet that displays work back to students and gives them a place to respond to specific questions.

Mr. Jacobson reflects on the grade. When I asked Mr. Jacobson why he gave her a D, he responded:

> She got a D because I didn't have any hard evidence of learning to grade to turn in, to show ... If [district technology director] Mrs. Schwartz said, "Hey, show me what Kira has done," I would have a couple reflections and that's it.

Having followed the events of her making the spinner and teaching others to do so, I asked him whether video evidence of this activity would have constituted evidence of learning. Mr. Jacobson responded:

> Yes and no. I wouldn't have accepted that because ... a big part of school is building your responsibilities, building what you need to do and kinda the real world aspect. So, you also kinda have to conform and do some of the things that you're supposed to do.

Mr. Jacobson made it clear, however, that he was extremely troubled about the D, and he wondered what he could have done differently. He saw the experience of Kira and her grade as part of his own professional learning, "part of my own formative [assessment]." He said that Kira had not "communicated out" her learning by producing the reflections but that "I'll own my part of that," suggesting that he needed to work on clarifying the expectations and setting harder deadlines. He mused as to whether the requirements for Kira might be changed:

> You kinda look at the [information from her advisor] and … with a student like that, maybe she doesn't have to do as many reflections, because that's a weak point, as long as she does what she's supposed to, right? I mean, that's really the key, is knowing your students.

When I spoke with Mr. Jacobson a few months later, he proposed an idea that corresponded with one of Kira's suggestions about an automatic tool that would support students in creating reflections and portfolios:

> I think my job as a teacher is to try to make sure that I'm putting in processes that can easily capture [artifacts and reflections] for them, so it's not strenuous or a lot of extra work, as well as satisfies outside people. So when we have board meetings or people who want to see numbers or quantitative results, that it kind of satisfies that as well. Like, I'm not doing it for the board members, but if I need their approval to understand how this program works, then these are the steps that I'm gonna try to make it as least obtrusive to the students so they can go with this really cool learning.

Mr. Jacobson and Kira thus both call for a new actor in the STEAM Lab, an artifact that would bridge the gap between the two logics. Kira's vision of a worksheet that featured images and video screen shots, along with space for a written reflection, would blend into the humanistic activity structure in the STEAM Lab by making students' creative products and reflections more seamlessly part of their work process. Recognizing her own experience with distraction—"it was a little too much when it was all on the computer"—Kira proposes that this instead be printed out and that time be set aside for students to complete it. Mr. Jacobson sees this approach as an idea that "satisfies outside people"—that is, renders the learning institutionally visible and authorized.

Conclusion

From the standpoint of the scientific essentialist logic, Kira deserved a D. All classes were graded, and Eagle Lake needed to measure Kira's learning. Mr. Jacobson created written assignments, billed as "reflections," that would make this learning visible and assessable in such a way that it "satisfies outside people." Kira had not done these assignments, and the grade accordingly reflected what Mr. Jacobson called "the real world aspect" in which "you kinda have to conform and do some of the things you're supposed to do." Elsewhere in school, Kira was unable to organize herself to produce the written work teachers demanded. It was no surprise, then, that she did not write the reflections in Tech21 either. In this view, Kira simply needed to learn to be more compliant with Eagle Lake's rules and procedures for grading. Maybe Kira had done some nice things in Tech21, but she had not produced anything in a form that Eagle Lake knew how to recognize and grade. The D, in this view, was on her.

And yet within the humanistic logic, the evidence of Kira's learning that Eagle Lake sought to locate and grade was hiding in plain sight. Clearly, Kira had acquired a difficult skill: fabricating a complex object that was not only functional but also met her peers' high aesthetic standards. Moreover, she had explicitly demonstrated what Mr. Jacobson and school and district leaders, during interviews, had repeatedly identified as valued capacities: collaboration, creativity, and persistence through challenge. Administrators spoke of the importance of recognizing the "whole child," and through her work, Kira had created a safe haven for herself in a school where she felt overwhelmed and threatened by academic and social challenges. Like Ted in the case reported by Stevens (2000a), Kira chose to ignore what she saw as the inauthentic make-work of the reflections and to focus instead on her projects, a stance that, I suggest, represented the kind of advocacy for herself that Eagle Lake, according to its "Progressive Education Definition," valued. Most importantly, she recognized in herself a possible future professional identity as a designer and entrepreneur, a view she reiterated and explicitly connected to Tech21 several months later when the I spoke with her for a final time. This achievement represented an awakening of something inside Kira—her "spirit," "soul," or "identity"—that both long-ago and present-day theorists view as the highest form of learning. Kira loved being in Tech21, worked hard, developed as a human being. The D, in this view, was on Eagle Lake.

I was troubled by Kira's case. The Tech21 experience echoed tensions documented in other implementations of FUSE: teachers recognized and valued the dynamic, collaborative work they could observe, but they needed to find something concrete to grade. As a learning scientist working in the design-based research tradition (Design-Based Research Collective, 2003; Barab & Squire, 2004; Brown, 1992; Cole & Packer, 2016), I considered ways in which the program might be revised based on findings from fieldwork. I reported to the FUSE team Mr. Jacobson's goals and concerns as he sought to adjust his professional practice in light of what he recognized as a traumatic experience for Kira. The FUSE designers began to explore a possible new tool for facilitators, which would take a step toward balancing the interests of the school in rigorous assessment with the interests of the learner in creative work and collaboration. Teachers would circulate in the studio, as Mr. Jacobson had with Kira and her friends, and take pictures and make notes of student work (see Stevens [2000a] for a proposal of such a tool). Together with the students' concurrent documentation and notes on their own project, the tool would automatically produce an artifact that schools may consider evidence of learning, while allowing kids to stay focused on the hard challenges that can be so meaningful to them.

CHAPTER 5

Conclusion

Two stories came together in this study. One is about a school district whose leaders had, for decades, spoken for the interests, freedom, goals, and concerns of students while struggling to reconcile these values with the objectives of documenting and measuring student achievement. Over time, the tension between these ideas had produced, as Dewey (1904) had predicted, a "maze of inconsistent compromise" (10). A century ago, the superintendent Alexander McHenry divided the school day in two, carefully assessing student achievement during the "common essentials" time while providing for student freedom, creativity and exploration during the "social and creative activities" of the afternoon. Over time, McHenry's reforms were scaled back, and the social and creative time gave way to an increased emphasis on core subjects with quantitative assessment. Electives were still present, but teachers prescribed moment-to-moment student activity and assigned letter grades. Mr. Jacobson, a teacher who saw "tremendous value in allowing the kids to be free," took his Tech21 elective a step further, allowing students to choose their activity. The century-old tension had made its way into Mr. Jacobson's class, however: students were free to make choices, but their work during these modern-day "social and creative activities" needed to be documented and graded. Eagle Lake's compromise in the STEAM Lab worked well enough for most students, but for those who had difficulty organizing their attention to produce written assignments, it would become a problem.

The second story is one of consequential learning and development by the students in the STEAM Lab. Students such as Gavin, Jenna, Ellen, Kyle, Cecilia, and Kira all learned difficult technical skills. Many, especially Kira, experienced personal growth in ways that mattered to them: being accepted into a high-status peer group, working as a valued member of a team, earning the respect of friends, developing the courage to share creative work with the world. Kira discovered a capacity for design she didn't know she had, and she found a place in the STEAM Lab where she could feel safe amidst the stressful academic and social environment of Eagle Lake. Her work to design and fabricate a fidget spinner and the ongoing teaching and coaching by Mr. Jacobson were so meaningful to her that, many months later, she would recall this experience and turn it into a metaphor for her own growing sense of agency.

For Kira, the intersection of the two stories produced a damaging outcome. The institutional residue of Eagle Lake's past and the values of the Board and the administration had produced an awkward attempt to reconcile the tension. Students were free to learn on their own in the STEAM Lab, but this learning would become institutionally visible at Eagle Lake—would "count" in ways that mattered to the school—only when reconstructed through graded written reflections. Kira, "distracted" by her focus on her creative work, didn't write her reflections, and the machinery of the rubrics and learning management system dictated a corresponding result: a D that caused trouble for her at school and at home. The compromise had produced both a powerful personal learning experience and a destructive grade that nobody—not Kira, not Mr. Jacobson, not the administrators who read about the case—interpreted as a true representation of her learning in the STEAM Lab.

In this final chapter, I first review the research questions and summarize my findings. I then address two important limitations: the use of a single-case research design and the setting of the study in the wealthy suburb of Eagle Lake. I describe potential future research directions suggested by this work. In a final reflection, I discuss the issues raised by Kira's case.

Research Questions & Findings

In this dissertation, I investigated the structured-choice Tech21 class in the STEAM Lab at Eagle Lake Middle School as an example of *humanistic* learning activity, drawing the term from its midcentury association with a form of education in which students "take self-initiated action … are capable of intelligent choice and self-direction … cooperate effectively … [and] work … in terms of their own socialized purposes" (Rogers, 1951: 387–388, cited in Cornelius-White [2007]: 114). The analytic chapters of this dissertation addressed this environment at three levels. I first considered the design and implementation of Tech21 as a case of organizational and institutional change, asking *how would a district establish and sustain an environment that provides students with freedom and choice?* I then turned to the learning experience of the students. Drawing on 6 months of ethnography, I explored the question *how do young people learn when given the ability to choose and organize their activity?* Finally, I examined the practice of the Tech21 teacher, Mr. Jacobson. Using interview and ethnography, I asked *how does a teacher organize and support an environment of freedom and choice?* I now summarize the answers to these research questions that have been presented in the previous chapters.

How Eagle Lake established and sustained Tech21

I interpreted the implementation of Tech21 in the STEAM Lab as a case of institutional change at Eagle Lake. Administrators and a teacher worked to install this humanistic learning environment, focused on the freedom and interests of the students, in a district characterized by an overall model of scientific essentialism that emphasized disciplinary instruction in academic subjects, monitored by tests. This process revealed a set of tensions and dilemmas (Cuban, 2001) which organizational actors carefully sought to negotiate. The administrators' communications to the Board in which they sought authorization for the new initiative used essentialist language, pointing to the “content and skills” it would develop in math, science, engineering, and technology. Anticipating that the “quants” on the Board would require measurement, administrators promised a corresponding scientific survey instrument. With the STEAM Lab then provisionally established using the scientific essentialist logic, the teacher Mr. Jacobson installed a humanistic environment, giving students freedom to direct their own learning and encouraging their personal development rather than instilling disciplinary knowledge. The technology administrator Mrs. Schwartz, concerned after the first year of Tech21 that the program did not offer sufficient structure, added FUSE Studio, a new actor that solidified the choice model but also reassured her that students would be improving their design and engineering skills through increasingly complex challenges. As Tech21 stabilized, it drew the attention of another teacher, the science department chair who coached the school’s Science Wizards team and wanted to use the STEAM Lab to advance this more essentialist program. Using a technique I described as interactional institutionalism, I analyzed a meeting among the science department chair, Mrs. Schwartz, and Mr. Jacobson and showed how the participants sought to advance their preferred logics through their language. Mrs. Schwartz ultimately chose not to facilitate a move of Science Wizards into Tech21, instead setting in motion plans for a potential new elective that would connect Tech21 with an industrial design class, preserving the choice-based structure of Tech21 while adding more sophisticated production tools. By 2019, Tech21 was becoming more firmly established at Eagle Lake through a series of negotiations in which organizational actors executed compromises among the competing logics. One compromise—students could be free to make their own decisions in Tech21, but would be assessed on written reflections—would come to affect the learning experience of a 7th grader named Kira.

How students learned

Students in Tech21 learned to use powerful software and assembled complicated devices as they created complex and sometimes original works of technology, art, and design. Using video-based ethnographic methods, I analyzed this learning process and developed a descriptive process model I called *constructive interaction*, a synthetic account of how students learned the design and technical skills they needed to achieve their goals. I found that students moved around the room or browsed through computer applications, ultimately identifying an object or activity that became the focus of their visual, auditory, and kinesthetic attention. They organized people and things as resources that would enable them to advance a project. Material and procedural models—including objects, people, or videos—provided guiding examples that enabled students to "figure out" how to construct concrete and digital structures. In some cases, students executed alternative designs and extensions that they thought made existing models "cool," "different," or "interesting," or that met some functional or aesthetic need. Students used the objects they made or shared them with others, an act that enabled them to achieve goals of social participation or to memorialize their activity. Ongoing constructive feedback on this work occurred through interactions with peers and with Mr. Jacobson, and the feedback they received served as a resource that they used in starting the cycle over again.

Many students discovered new interests and experienced personal and social growth. I traced this growth through a set of ethnographic cases of student learning. In "Cecilia, The Shy Person," I documented a student's developing identity as a practicing artist. Initially reluctant to share her work, over the course of the trimester Cecilia developed enough confidence in her artistic ability to finally start an Instagram and share her work publicly. In "No 'I' In Team," I told the story of Ellen and Kyle, two young people who had been identified as "special needs" students by Eagle Lake. Ellen and Kyle worked together to assemble a complex technical device, a small light-powered car, failing on 14 consecutive tries to execute a difficult challenge with the car before finally succeeding. This story recalled a case documented by McDermott (1996) of a student whose "learning disability" was less apparent in some contexts than others: Kyle and Ellen worked fluidly when the challenge gave them a path in which they could succeed, but Kyle had difficulty with a year-end portfolio that Mr. Jacobson required. In "The Minecraft Hill Community," an aspiring coder named Gavin used his skill to design a modification in Minecraft that gained him status with a pair of higher-status boys, a case that demonstrated the social dimension of learning in the STEAM Lab. Similarly, in "#squadnecklace," Jenna was motivated to design a complex and original piece of jewelry by her desire to memorialize her friend group in advance of her imminent move out of the country, showing the power of social connection and recognition as a motive for self-sustained activity. I used the story of "The Cardboard Chair" to highlight a gap in previous theorizing on interest and learning (De Garmo, 1911; Dewey, 1913): Maxine, already seeing herself as an engineer, designed and built a chair out of cardboard, motivated by her joy in simple designing, tinkering, and constructing with technical materials.

How Mr. Jacobson taught Tech21

I answered the third research question—how a teacher would organize and support an environment of freedom and choice—more narrowly. Mr. Jacobson's vision for Tech21 involved students organizing their own work activity, and he moved around the room acting as a facilitator, coach, and materials manager more than an instructor. However, I noticed a case that resonated with the first two research questions and surfaced a specific dilemma faced by Mr. Jacobson and, by extension, other educators providing freedom in their classrooms: how learning in the STEAM Lab would be assessed. Because disciplinary instruction was not Mr. Jacobson's core objective, he did not have the conventional school-authorized assessment toolkit (quizzes and tests) available to other Eagle Lake teachers. His objectives instead were principally humanistic: the personal growth of the students and their acquisition of what he called the "four C's" or so-called soft skills. Such objectives, however, were institutionally invisible (Stevens, 2000a) at Eagle Lake; although administrators spoke for them, they did not provide Mr. Jacobson with tools to assess them. Kira, a 7th grader struggling to navigate the challenging academic and social environment of Eagle Lake, presented this dilemma for Mr. Jacobson. Kira found a home in the STEAM Lab, where she developed significant expertise as a 3D designer and earned the respect of her peers as she taught them difficult skills. "It's unimaginable that I can do this kind of stuff," Kira reported, "I never thought I'd be doing that." Through this project, she had experienced a consequential change, recognizing in herself a new identity and capacity as a designer and teacher, a transformation in what Holmes (1912: 52) called her "heart and mind and soul."

Mr. Jacobson struggled, however, to find what he and administrators called "evidence of learning" from Kira. The scientific essentialist logic at Eagle Lake dictated that Mr. Jacobson locate some concrete assessable items in classroom activity and assign a letter grade. Accordingly, he had developed a rubric that required written reflections and a portfolio, an activity seen by other students as ritualistic make-work and which Kira had chosen not to produce. Kira's resulting poor grade was damaging to her, causing trouble at home and making it impossible for her to continue in Tech21 in 8th grade. I presented a set of responses from

Eagle Lake's professional staff on Kira's story, as well as from Kira herself and proposed possible changes to the grading system that could benefit students like Kira. Perhaps high grades could be based on hard work, Kira suggested. Or maybe the problem was in the way in which the required reflections and portfolio were presented as a side activity, rather than being integrated into the daily work process, which made it difficult for students like Kira who were known to require clear direction on school-assigned work. Her proposals echoed ideas circulating among the FUSE program designers: an application that teachers could use to capture qualitative measures of student achievement as they made their rounds through the classroom, and more accessible reflection and documentation tools that students could use to capture their work.

Limitations

This study has two significant limitations. First, as a single-case study of one school in one district, it centers the particularities of that class, that school, and that district (Becker, 1990). As documented in Chapter 1, the Eagle Lake school district is an outlier among American schools, with a long history of involvement with the progressive education movement and a modern-day reputation as a progressive school. Although I showed that even Eagle Lake's administrators take pains to note that the school is "more traditional than folks would claim," the humanistic learning environment of Tech21 thus likely emerged in a more facilitative context than it would have in other districts. The hiring of educators and administrators inclined toward student freedom and interest, which may not have occurred in a district that emphasized more traditional educational goals, was pivotal in the development of the Tech21 class.

Second, Eagle Lake is not just a wealthy community, but an exceptionally wealthy community. Eagle Lake parents were among the financial elite of American society, and many of the students I spoke with were headed to prestigious boarding schools. The stakes for Eagle Lake were high—parents pressured the school board and administration to prepare students academically for entrance exams, and many students in turn felt pressure from their parents to achieve academically. And yet the stakes were in a sense also not so high, as many students enjoyed a safety net of personal and family connections that would likely ensure their future success, and as out-of-school learning activities such as clubs and tutors built academic and social skills. The district could thus afford to dedicate some instructional minutes to what an earlier generation of critical parents had called "fads and frills" like the free-choice environment of the STEAM Lab, an option that may not be available in other districts. The economic status of the area shaped the perspectives that grounded this dissertation in a different sense as well: I grew up in a less wealthy but still very prosperous nearby suburb and am fortunate to have an upper-middle-class lifestyle, meaning that in ways both conscious and unconscious I share the world view of the people I was researching.

These factors make it difficult to generalize from this single case. However, it is a reasonable goal for the qualitative researcher investigating a single-case context to consider a social phenomenon as "a process, the same no matter where it occurs, in which variations in conditions create variations in results" (Becker, 1990: 240). Administrators everywhere face the challenge of making arguments to school boards to secure funding; within schools, educators vie for scarce resources during tense meetings; within classrooms, students are expected to make things (whether light-powered cars, math worksheets, or history essays) and seek out models that help them figure out how to meet standards for performance. The findings in this study may provide a basis for comparison to identify similarities and differences in these phenomena in other contexts.

Future Directions

In this study, I developed diverse lines of analysis to look at Eagle Lake from several levels. I used tools from institutional theory to conceptualize *instructional logics* and to locate these logics in written materials (such as memoranda to the Board) and in moment-to-moment interaction (such as the meeting to discuss access to the STEAM Lab). This latter technique, which I called interactional institutionalism, can generalize to other contexts and be used as a methodological tool and analytic framework in studying school and district decision-making processes. I also developed a process model of learning in the STEAM Lab, which I called *constructive interaction.* As described in Chapter 3, the constructive interaction model may have prescriptive, diagnostic, and predictive implications for the design of both project-based and traditional learning environments. For example, the finding that students consistently relied on material and procedural models to advance their work suggests that (a) designers of learning environments should provide ample clear models of successful practice, (b) students who struggle may not have been able to access the right kind of models that would guide their work, and (c) if models are available, students will draw on them as resources. Analyzing traditional instructional environments using the constructive interaction process model represents one potential extension of this research: the steps of the model could be compared with their analogues in a traditional environment to surface comparisons. For example, in observing a science class at Eagle Lake I noticed that students tried to coordinate their work to solve a problem presented by the teacher, an effort that was productive in Tech21 in many ways but was specifically discouraged in science class. Finally, the difficult case of Kira and its dilemmas of assessment represents an area of future work. I have discussed the case at length with Mr.

Jacobson and we have together considered different approaches, described briefly in the concluding reflection below, that may improve the experience of similarly situated students in the future. This work may provide, then, a starting point or comparative example for schools and districts seeking a "reasoned balance of interests" (Kridel & Bullough Jr., 2007: 32) as they develop learning environments that provide increased freedom and choice to young people in school.

Concluding Reflection: Towards a New Compromise

In this dissertation, I sketched a typology of diverse visions of school's purpose. An *essentialist* perspective emphasizes the transmission of cultural discoveries and achievements in science, mathematics, and the humanities to each new generation. A *scientific* view holds that the progress of each individual learner should be carefully studied and monitored through a regime of rigorously designed assignments and tests. The *humanistic* view holds that school should be organized to achieve the fullest possible development of human potential, with an emphasis on supporting the freedom and interests of the individual learner. These perspectives may be translated into everyday practice as *logics,* each with its own set of rules, assumptions, artifacts, and accountabilities. In the preceding chapters, I have shown how these logics came into conflict at Eagle Lake. The STEAM Lab, designed in accordance with humanistic principles, produced substantial learning, growth, and personal development for many students, especially Kira. At the same time, Eagle Lake's institutional stance on assessment based on documentation and reflection led to a conflict. Kira did not produce the "evidence of learning" called for and experienced a difficult outcome as a result.

Eagle Lake, like nearly all American middle schools, offers students a vigorous program of scientific essentialism. Standards-aligned instruction in reading, math, social studies, and science—what its progressive-era superintendent McHenry called the "common essentials"—defines the day-to-day experience for young people in Eagle Lake. Graded assignments and rigorous assessments produce evidence of learning that satisfies anxious parents and a school board concerned with data and accountability. A century ago, however, that experience represented only part of the school day. Though trained as a scientist, McHenry's professional learning community—a national and international network of progressive educators, along with the child-centered educators and administrators he recruited to Eagle Lake—guided him toward a strong humanistic stance. Drawing on a conception of education that united the Kilpatrick and Deweyan strands of progressivism, McHenry came to believe that the social and creative activities were the "vital, life-giving part of the curriculum." Education, he believed, involved "drawing out the child himself [*sic*]". McHenry and his colleagues designed a humanistic program for the afternoon in order to achieve this goal and yet

> [McHenry's] background in science and the effort he and his staff put forth to construct a 'scientific curriculum' in the teaching of the common essentials made him quite conscious of the lack of objective means to measure the success of that part of the curriculum which was devoted to social and creative activities. He made several attempts to devise measurement techniques, but made little progress. (Talcott, 1962)

A century later, the administrators at Eagle Lake faced the same challenge and were equally adrift. Asked about her goals for this research project into the STEAM Lab, Dr. Karlssen responded:

> We need to be able to clearly define evidence of student learning that doesn't have to be these quantitative measures. … We all can go into an environment [like the STEAM Lab] and listen to kids and know that it's a good thing. We feel it. You can talk to kids and hear what they have to say, but how do we communicate that ... how do we monitor that, and make sure that's happening?

The administrators at Eagle Lake were not alone. Researchers during the 2010's were grasping for "instruments" to "measure" "non-cognitive" skills (e.g., Duckworth & Yeager, 2015; West et al., 2016).

Perhaps it is, simply, not possible to measure this development to anyone's satisfaction. Maybe quantification and the search for objective, outward evidence change can only produce representations of learning that have been "distorted into clarity" (Law, 2004: 2). Stevens (in preparation) proposes Law's Law: "we want our accounts of learning to be as messy as they need to be, and no less." None of the learning stories I report in Chapter 3 could be represented on a spreadsheet. The most consequential changes—transformations in what Holmes (1912: 52) called the "heart and mind and soul" of these young adults—could be seen and heard and felt, experienced alongside the student, but not measured and compared. Cecilia developed enough confidence in her artwork to finally start an Instagram and share her work publicly. Ellen and Kyle failed on 14 consecutive tries to make their light-powered car work before finally succeeding. Gavin designed a passageway in Minecraft that earned him entry into a tight-knit pair of high-status boys, then worked on coding an alarm system to respond to the griefing and trolling on the class server. Kira, troubled and overwhelmed in school, found a place of safety, trust and growth in the STEAM Lab, where her emerging expertise as a designer was valued by her peers. Student achievement in the STEAM Lab was just that: the achievements that counted for students (Stevens, 2010). These "outcomes" were radically heterogeneous, as diverse as the young people themselves, and beyond any system of measurement. Eagle Lake's best efforts to quantify the experience consisted of awkward survey questions designed by educational technology vendors, which students checked off quickly and mindlessly.

With the steady incursion of the scientific logic—the "data monster," as one administrator called it—into all aspects of the learning experience at Eagle Lake, today's social and creative activities came with a price tag: a consequential assessment. Many students focused on navigating Mr. Jacobson's rubric, producing superficial weekly reflections that received high marks and uploading pictures of their work to fill out the year-end portfolio. Others, like Kira, for complicated and diverse reasons, could not bring themselves to do what Eagle Lake asked of them in return for a high grade.

Cuban (2001) writes about the "wicked problems" of education:

> ill-defined, ambiguous, complicated, interconnected situations packed with potential conflict [that] arise when people compete for limited resources … hold conflicting values … and wrestle with diverse expectations held by others about what practitioners should be doing. (10)

Cuban calls these *dilemmas*: "messy, complicated, and conflict-filled situations that require undesirable choices between competing, highly prized values that cannot be simultaneously or fully satisfied" (10). Such were the dilemmas at Eagle Lake. The "quants" in the community and on the school board pressured Eagle Lake to move toward a regime of pervasive measurement. Teachers and administrators recognized the value of humanistic learning—"we feel it," said Dr. Karlssen—but sought, in vain, a language in which to communicate what they knew to be happening. They were internally divided, not only among each other but within themselves, as they sought to balance the interests and freedom of students with the need for objective measurement of progress in the common essentials.

Dilemmas cannot be solved, they can only be managed, with a goal of creating "better compromises" (Cuban, 2001: 16). With the scientific logic ascendant everywhere at Eagle Lake, I suggest that its commitments, implications, and accountabilities—including rubrics and letter grades—could, perhaps, be eased off in the STEAM Lab to achieve a better compromise among the diverse goals of the stakeholders, a new balance of competing interests.[25] Eagle Lake's historical compromise provides a possible model for its modern-day policies. Students at Eagle Lake a century ago were rigorously assessed and graded on the common essentials, but experienced "social and creative activities" without the rewards, penalties, and consequences of letter grades. One option for Eagle Lake is a pass/no-pass marking system for the electives, along with a strong system of feedback for and dialogue with students about their work and their own development. Alternatively, as Mr. Jacobson suggested during our final conversation, students could grade themselves, or he and the students could "assess together, to really see where they're thriving and where they need assistance." Any of these ideas could help to disconnect the normalizing judgment of a letter grade from the experience of personal development and growth. Perhaps most importantly, a new tool in the STEAM Lab, proposed by both Kira and Mr. Jacobson, could prompt students to reflect as they work and also give teachers the ability to document learning achievements in context. Such a tool could produce "evidence of learning" that is both authentic and institutionally visible. With such a tool embedded into her creative practice and the daily routine, Kira would not have had a problem with "distraction" and would have had the step-by-step concrete direction that she needed for school-directed assignments. Mr. Jacobson, who noticed Kira's growth and her productive interactions with her peers, would have had a channel to document that and make it visible for anyone who might want to see it. It is my hope that this work, and the vision of such an assessment tool, may provide guidance for schools and districts seeking to negotiate the tensions and ambiguities of

[25] Egan (1997; 2008) argues that a productive equilibrium among the competing goals for modern schooling is in fact impossible to achieve, as any compromise seeks to reconcile contradictory and mutually incompatible objectives, and proposes an alternative framework based on "kinds of understanding."

instructional practice as they design learning environments that provide increased freedom and choice to young people in school.

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