EXPLORING COLLABORATIVE DESIGN IN A PK-12 CREATIVE WRITING CHALLENGE

A Dissertation Presented to the
Faculty of the College of Education
University of Houston

In Partial Fulfillment
of the Requirements for the Degree

Doctor of Education

by

Shaunna Smith

July 2012

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July 2012

Acknowledgment

Often we find ourselves trapped by our own fear and self-doubt. Bayles and Orland (2001) explain it in *Art and Fear*, "you cling ever more tightly to what you already know you can do – away from risk and exploration, and possibly further away from the work of your heart." This dissertation is proof that I took a blind leap of faith and lived to tell the tale.

Given that most of my words have been devotedly crafted into this dissertation, I am fairly certain that the words that I have remaining are not eloquent nor are they adequate enough to acknowledge and give thanks to the many who facilitated my journey. Alas, I will try my best.

Family: The Rocks and the Cheerleaders

My husband, Mark, who provided me with laughter, *inspiration*, insight into creativity, reminded me each day that I was awesome, and held me lovingly each time I fumbled.

My daughter, Nadia, who reminded me that *rainbow* is the best color and that a life worth living involves taking some time to pause and enjoy the wonder in a fallen leaf, an unknown bug, or the way a window can cast a rainbow on the kitchen floor.

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Dr. Robin, who fiercely *advocated* for me from beginning to end. Dr. McNeil, who *cleverly* solved problems with a single bound. Dr. Day, whose *charisma* empowered me to push onward and enjoy the ride. Dr. Mountain, who inspired me to write and provided a *calming* beacon of hope after each storm. Dr. Flowers, who championed that *art* and STEM support one another. Dr. Craig, whose compassion and *fearlessness* inspired me to not only find my voice, but to have the courage to share it with others.

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An Abstract
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Abstract

This study explored how PK-12 participants in the *CSTEM Creative Writing Challenge* engaged in a collaborative design project to produce a creative non-fiction pop-up book. As both collaboration and creativity are recognized as invaluable skillsets for success in the competitive 21st century economy, they served to focus the inquiry into this constructivist project-based learning (PBL) experience.

Using ethnographic methods, this exploratory study wove narratives of student participant experiences and incorporated a variety of data, including product quality ratings derived from a rubric, student-created reflective videos, and a focus group interview. In addition to the researcher, the data were examined by two peer debriefers and one external auditor to ensure trustworthiness. The resulting naturalistic inquiry may provide transferability of a potential framework for PK-12 teachers who wish to engage in similar collaborative design experiences with their own students.

The cognitive benefits (including process and multiple literacies) and psychosocial benefits (including altruism and life lessons) that these students voiced throughout their reflection provided a testament to constructivism and experiential learning. Statistical investigation showed that ratings of the pop-up book product did not parallel ratings of the process; however, this study maintained that presenting students with the opportunity to engage in inquiry-based video making of their PBL experience allowed students to authentically and formally address the life lessons they developed.

Table of Contents

List of Tables

Table Page

List of Figures

Figure Page

Chapter I

Introduction

A DJ spins music which is booming from large speakers throughout a room while 1,500 people are dancing and socializing. Bleachers are filled with people cheering excitedly for groups on the center stage. It's a Saturday morning in March. What is this? Is this a party? Is this a concert? Actually, this is the CSTEM annual academic competition at the George R. Brown Convention Center in Houston, Texas, and this is definitely not your typical academic experience.

These 1,500 people range from PK-12 students, teachers, parents, family members, and community volunteers from across the country. School bands proudly play theme songs as individuals wave banners and chant cheers to support their teams. Booths and exhibits surround the convention hall as the students showcase a year's worth of their hard work that ranges from art, engineering, robotics, and writing. As teams, they have spent countless hours preparing for today, the final competition, where they will challenge one another and see who takes home the coveted trophy.

What is CSTEM?

CSTEM (Communication, Science, Technology, Engineering, and Mathematics) is a Houston-based non-profit organization which supports a year-long afterschool program in which I am one of six curriculum developers and teacher trainers (Table 1). With an emphasis on the importance of STEM enrichment and the need for creativity and collaboration, CSTEM is one of the U.S.'s earliest PK-12 STEM programs (Koebler, 2011). With humble beginnings in a Houston middle school ten years ago, it was founded with the mission to provide the necessary supports to "reduce the achievement gaps in

areas of CSTEM through focused teacher training, experiential learning for students through practical application and exposure to careers in related communication, science, technology, engineering, and mathematics fields for grades PK-12" (CSTEM, 2012). Though STEM is at the heart of the program, the "C" for communications encompasses visual and verbal artistic expression as well as challenges the students to concisely communicate throughout many facets of the challenges.

In order to be competitive in the 21st century, creativity and collaboration are skills which must be fostered in students. The Partnership for 21st Century Skills (P21) contended that students should have the capacity to think creatively, work creatively with others, and implement innovations (2011). This was echoed by a variety of national education organizations as seen in related standards and objectives including, the need for students to have a capacity for creativity and collaboration, whether in the development of thought, verbal communication, or the physical act of making meaning to demonstrate knowledge and self-expression (International Society for Technology in Education [ISTE], 2011; National Arts Education Association [NAEA], 2011; National Council of Teachers of English [NCTE], 2010). This growing interest in fostering creativity and collaboration, which are both process-based tasks, cannot be quantified on the standardized norm-referenced tests upon which our educational system relies. Such skills cannot be relegated to multiple choice questions to be graded by scantrons. In support of this educational concept, CSTEM encouraged interdisciplinary exploration through project-based learning with challenges that included creative writing and bookmaking, robotics, global information systems (GIS), green environmental solutions, community murals, and sculpture.

CSTEM is financed through corporate sponsors, such as Schlumberger, Shell Oil Company, and AT&T, as well as business partners which include the University of Houston, Delta State University, and various local and state government officials. Through this support CSTEM is able to provide all of the necessary materials, training, and funding for all teams to travel to Houston, Texas for the annual competition in March at the George R. Brown Convention Center. Additional funding is set aside to provide trophies and medals to winners, as well as scholarship awards to students who exceed in leadership and performance throughout the competition.

Table 1

What is CSTEM?

WHAT	WHY	WHO	HOW	WHEN
CSTEM = Communications, Science, Technology, Engineering, & Mathematics	Provides professional development and academic competitions to help reduce the achievement gap in CSTEM related content areas.	Advisory board, industry experts, content specialists, curriculum developers, teacher trainers, interns, and volunteer judges.	Financed & supported by Schlumberger, Shell Oil Company, AT&T, University of Houston, Delta State University, and various local and state government officials.	Week long teacher training in August with workshops twice a month via synchronous online learning environment. Culminating competition is on March 31, 2012 in Houston, Texas.

Goals and Purpose

The purpose of this study was to explore how PK-12 participants in the CSTEM Creative Writing Challenge engaged in collaborative design to produce a creative non-fiction pop-up book. Three goals were at the forefront of this exploration: 1) Intellectual Goal: to explore how PK-12 student participants collaborate in the design experience in the CSTEM Creative Writing Challenge; 2) Practical Goal: to explore the relationship

between the process and the product (which is often overlooked in traditional assessment); and 3)Personal Goal: to explore the participants experience in the challenge in order to improve my own instruction and curriculum development for future challenges.

Research Questions

The following questions guided this study:

1. What design processes do the feeder pattern teams use in the CSTEM Creative Writing Challenge? (Hypothesis: Each team will describe instances that can be categorized within the stages located in the literature, but will vary in their uses of iterative sequences, collaboration, and reflection.)
2. What is the relationship between the design processes used and the effectiveness of the final products? (Hypothesis: The more collaborative, iterative, and reflective the process the more effective the final product will be.)

Chapter II

Literature Review

This chapter provides examples of literature as they relate to the themes explored within the study. The constructivist theoretical framework will explain epistemological beliefs in relation to basic constructs within the study. Creativity and design thinking will be explored as fundamental skills and habits of mind, which are required for creative endeavors. Collaborative design and its processes will be explored as a means of putting creativity and design thinking into action. Factors that contribute to collaborative design, including structures, work flows, and tools, will be explored to shed further light into the practical implementation of collaborative experiences. And lastly, the context of the *CSTEM Creative Writing Challenge* will be explored in relation to the writing process, collaborative writing, and pop-ups and paper engineering, as they are the foundation for the collaborative design experience under study.

Theoretical Framework

Constructivism serves as the theoretical framework for this study as it promotes the belief that knowledge is constructed through a learner's active engagement with quality experiences, a desire to purposefully make meaningful products while learning by doing, and is encompassed by opportunities for social interactions (Dewey, 1938; Gagnon & Collay, 2001; Piaget & Inhelder, 1969). The notion that learning results from transformative experiences has been championed by other constructivist learning theorists, such as Bruner (1974), Greene (1995), and Kolb (1984), as they contend that *experiential learning* enables learners to be able to reflect and think critically about their experiences in order to derive meaning from them.

Sonnenwald (1996) further demonstrates the important role of experience with her visual synthesis of learning in a design context (Figure 1). Through the explorations of past and current experiences, both designers and learners can reflect in order to create new artifacts, experiences, and knowledge.

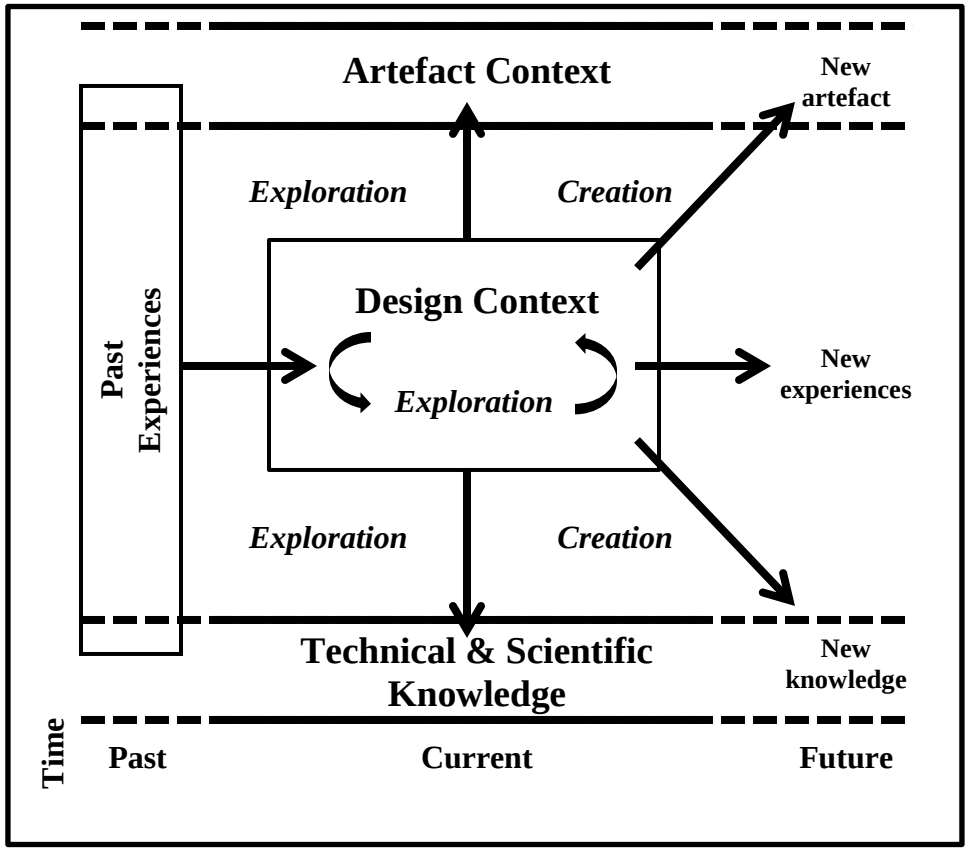


Figure 1

Sonnenwald's (1996) *Knowledge exploration during the design process* (p. 278).

Project-based learning (PBL). In PK-12 education, most design activities are addressed through project-based learning (PBL). This type of experiential learning allows the teacher to be a facilitating guide while the students take charge of their own multi-phased inquiry (Savery & Duffy, 1996). As supported by Hmelo-Silver (2004), this type of flexible learning promotes psychosocial growth and develops intrinsic motivation.

Hmelo-Silver's research contended that, "PBL is an instructional approach that offers potential to help students develop flexible understanding and lifelong skills" (abstract). Constructivist learning, which "cast[s] learners in the role of instructors and knowledge communicators rather than information recipients" (Harel, 1991) authentically prepares students with the necessary skills for the competitive 21st century economy.

Collaboration in learning and design. The concept of collaborative learning is what cognitive scientists refer to as *distributed cognition*, or the learning power of group intellectual efforts. Smith and MacGregor (1992) agree with constructivist beliefs, but add that collaborative learning benefits from groups that contain diverse individuals, including diverse backgrounds, learning styles, experiences, and aspirations. Design education researchers agree and refer to these diverse learning communities as *communities of innovation*, in which collaborative groups benefit greatly from diverse perspectives (Sawyer & DeZutter, 2009, p. 81; West & Hannafin, 2011, p. 821). Sawyer (2007) notes that, "[c]ollaboration drives creativity because innovation always emerges from a series of sparks, never a single flash of insight" (p. 7).

Creativity and Design Thinking

Creativity is a domain that is not limited to one field or subject area, because of this it is difficult to define. As a construct in this study, creativity is defined as the ability to generate unique ideas. Many researchers, as well as artists, designers, and engineers, who write about their own methods, contend that creativity is not necessarily an inborn trait but that it can be fostered as a state of mind which one nurtures and develops into a series of habits (Csikszentmihalyi, 2008; Pink, 2006; Root-Bernstein, R. & Root-Bernstein, M., 1999; Tharp, 2003).

Research on creativity has evolved from the 1950's focus on an individual that has creative characteristics, to the 1980's focus on an individual with creative characteristics and creative resources, to the more current focus on an individual being part of a creative collaboration that is embedded within a social group. Similar to constructivism and theories of collaborative learning, this view, referred to as *distributed creativity*, acknowledges that creativity is distributed across groups and social systems as they collaborate to design a shared creative product (Craft, 2003, p. 115; Sawyer & DeZutter, 2009, p. 82). The transition from focusing on the efforts of the *creative individual* to the *creative collaborative group* informs assumptions of knowledge in which Gee (as cited in Sawyer & DeZutter, 2009) maintained that:

> Knowledge and intelligence reside not only in people's heads, but are distributed across situated social practices that involve multiple participants in complex social systems. 'Knowing' is reconceived as the ability to participate appropriately in these shared cultural practices. In the distributed cognition perspective, mind is considered to be; social, cultural, and embedded in the world. (p. 83)

One of the biggest challenges facing the educational community is the paradox between what is said and what is actually done. As a collective, they state that they support fostering creativity and collaboration as processes worthy of inclusion in the classroom, however, their focus remains on learning outcomes and assessments (Eisner, 2002; Greene, 1995). Many researchers indicated that there are a variety of benefits to engaging in creative and collaborative opportunities; however the difficulty to quantify

them as curriculum requirements hinders most educators from actually doing so (Bryan, 2004).

Design thinking: Creative skills and habits of mind. As a designer, creative problem-solving skills are paramount. Effective designers must have a variety of skills that include design thinking, which is embedded within applied art and applied science (Canales, 2010; Findeli, 2001; Lawson, 1990). These strategies and methods vary in the research; however, there is agreement that design thinking skills involve a divergent mindset, which allows designers to engage in the creative exploration of a task or problem, reiterative experimentation to uncover the best solution, and the ability to reflect upon the process along the way (Brown, 2008; Michalko, 2001; Root-Bernstein, R. & Root-Bernstein, M., 1999).

Using a human-centered approach, Brown (2008) grouped design thinking strategies into five categories including empathy, integrative thinking, optimism, experimentalism, and collaboration. While in agreement that collaboration is important for creativity, Michalko (2001) focused on the characteristics of being creative, or what he terms "creative genius," and he identifies the secrets of creative genius as the basic tenets of creativity and design thinking, which involve "seeing what no one else is seeing" and "thinking what no one else is thinking" (p. 15-18, 81-84). The Root-Bernsteins (1999) presented similar design thinking strategies by expanding them to 13 distinct "sparks of genius" including specific actions for achieving creativity. By experimenting with these types of strategies, creative individuals and groups become imaginative explorers who attempt to generate as many ideas as possible, knowing that most will fail, but it is those few gloriously innovative ideas which will be undeniably

effective. This is what others refer to as "productive failure" (Kapur, 2006) and "an 'a' in failure" (Tharp, 2003). *Table 2* summarizes variations of design thinking strategies below.

Table 2

Variations on Brown's (2008) Design Thinking Strategies: Creative Skills and Habits of Mind

	Empathy	**Integrative Thinking**	**Optimism**	**Experimentalism**	**Collaboration**
Michalko (2001)		• Knowing how to see and making thoughts visible • Thinking fluently • Making novel combinations	• Finding what you're not looking for	• Connecting the unconnected • Looking at the other side • Looking on other worlds	• Awakening the collaborative spirit
Root-Bernstein, R. & Root-Bernstein, M. (1999)	• Empathizing	• Observing • Imaging • Abstracting • Recognizing patterns • Forming patterns • Analogizing • Body thinking		• Dimensional thinking • Modeling • Playing • Transforming • Synthesizing	
Tharp (2003)	• Harness your memory • The long run (life habit)	• Rituals of preparation • Before you can think out of the box you have to start with a box • Spine (essence) • Skill (the nuts and bolts of your craft)	• Accidents will happen • Ruts and grooves • An "A" in failure	• Scratching	

Collaborative Design

Design is vital in today's culture where almost everything is in fact designed, whether it is the favorite coffee mug used to drink some morning coffee or the fashionable SmartPhone used to read the day's top stories. "Good" design manages to find a way to merge attractiveness and functionality. Norman (2002), a renowned cognitive psychologist who specializes in human-centered design, stated "[t]here is no

need to sacrifice beauty for usability, or, for that matter, usability for beauty…good designs will have it all – aesthetics pleasure, art, creativity – and at the same time be usable, workable, and enjoyable" (p. 1). Naturally collaborative, design is about communication in that it is objective and audience-driven. Whether resolving a challenge or generating an innovative object, design involves intentional planning and problem-solving (Findeli, 2001; Mirza, 2011). The level of success of a design is measured by how well it conveys an idea, feeling, or function to its intended audience (Brady, 1998; Norman, 2002).

For the purposes of this study in a K-12 afterschool setting, it is very important to understand how individuals negotiate all of the challenges faced in a collaborative design process. Therefore, the roles of each individual within the collaborative group as well as the specific design-thinking strategies they use within the process must be identified and analyzed in context. Structures of teams and the collaborative workflows are identified in the literature as key themes that must be understood in order to make more meaning of the design processes that they use to achieve productivity/quality.

Design processes: Putting design thinking into action. Historically, understandings of design processes have evolved from the original linear model of a two-phase process involving the *act of defining a problem* and the *act of designing a solution*. However, in the 1960s it was acknowledged that each new design challenge presents many "wicked problems" for designers; therefore researchers began to seek ways to uncover the steps that happen in between (Buchanan, 1992, p. 15). Because the nature of the design task affects the process that must be undertaken there is not *one and only one* design process. However, current research acknowledges that design processes are non-

linear, iterative, and consist of a basic shell that includes a variation of the following foundations of inquiry: define, research, ideate, prototype, choose, implement, learn, reflect (Chiu, 2002; Dziersk, 2006; Findeli, 2001; Lawson, 1990; Rayala, 2011; Sawyer & DeZutter, 2009; West & Hannafin, 2011).

Figure 2 shows Chiu's (2002) process model of design collaboration, which describes three states: 1) the initial state, in which criteria and intentions are identified; 2) the design state, in which designers consult, negotiate, make decisions, and reflect; and 3) the final state, in which the solution (or end product) is presented (p. 206). This model results from a qualitative study on the collaborative design processes of architecture firms and expresses the basic role of collaboration, as seen in the phases that involve negotiation, decision-making, reflection, and consultation. Chiu's model does not however elaborate on the specific design thinking skills/actions that facilitate the process; therefore it does not provide specific suggestions to assist with the facilitation of such a model in a PK-12 context.

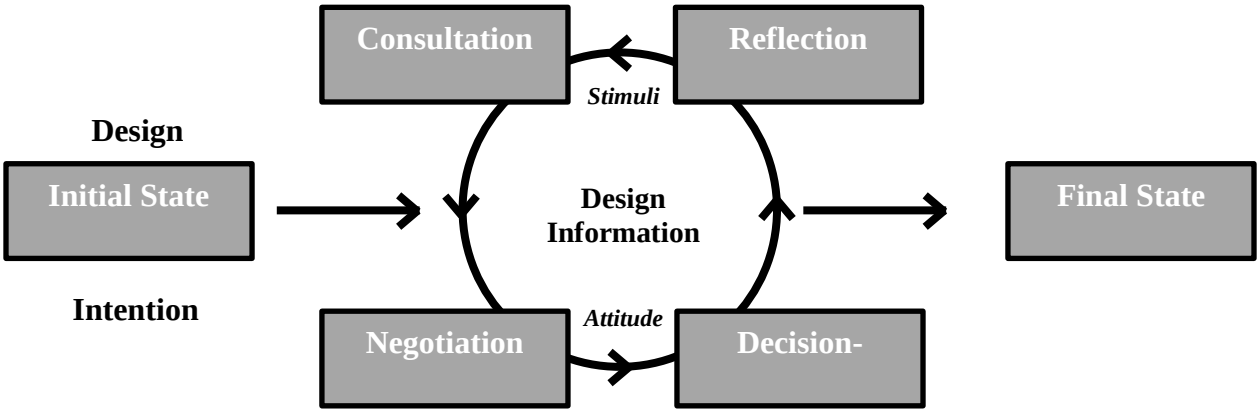


Figure 2 "A process model of design collaboration" (Chiu, 2002, p 206).

IDEO, an internationally recognized creative design firm, and Riverdale Country School, a New York City school, sought to collaborate to create a functional design

thinking toolkit made especially for teachers. The result, *Design Thinking for Educators* (2011), provides a guide that contains examples from three case studies, and delivers materials for students and teachers to employ design thinking methods to design for social change. Agreeing that diverse teams will facilitate effective collaboration, the guide provides advice on how to structure the teams as well as how to foster productivity. One of the key features of the guide is the working model (Table 3) that succinctly describes design thinking skills and methods as they are implemented over the course of a design process. With an intentional focus on how to use the process to solve systematic educational issues through the design of experiences as opposed to the design of physical products (i.e. *How might we create a 21st century learning experience for our students? How might we create a culture of collaboration? How might we develop games to tackle the toughest learning hurdles?*).

Table 3

"The Design Process" from Riverdale Country School & IDEO's (2011) Design Thinking for Educators (p. 4).

PHASES	**Discovery**	**Interpretation**	**Ideation**	**Experimentation**	**Evolution**
STEPS	1. Define the challenge 2. Prepare research 3. Gather inspiration	4. Tell stories 5. Search for meaning 6. Frame opportunities	7. Generate ideas 8. Refine ideas	9. Make prototypes 10. Get feedback	11. Evaluate learnings 12. Build the experience

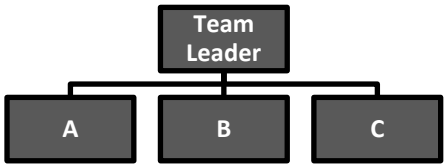
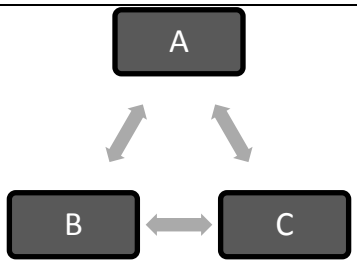
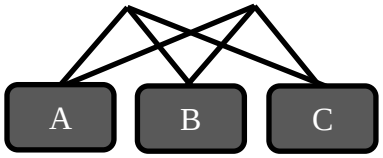
Collaborative design structures: Configurations that foster productivity. The manner in which a collaborative team is organized or structured is significant as it informs the efficiency of the collaborative design process, which in turn affects the quality of the design. Diversity is a key characteristic for effective collaborative design and should include members with diverse abilities, backgrounds, experiences, and perspectives, in order to achieve diverse thinking (Grefe, 2010; Smith & MacGregor, 1992; Sawyer, 2007; Sawyer & DeZutter, 2009; West & Hannifin, 2011). Sonnenwald's (1996) research indicates that the distribution of roles is another important characteristic of a collaborative team. Roles can vary in complexity or importance and can range by boundary type, which include *organization*, *task*, *discipline*, *personal*, and *multiple* (p. 290). Leadership directly relates to the distribution of roles, their complexity, and essentially affects the effectiveness of the overall collaborative design effort.

Combining terminology from Chiu (2002) and Maher as referenced in Kvan (2000), there are a variety of structures that can represent how teams are organized and interact, which include Hierarchical Team/Dictator Collaboration, Parallel Team/Exclusive Collaboration, and Hybrid Team/Mutual Collaboration (Table 4). The first structure, Hierarchical Team/Dictator Collaboration, involves one person who is in

charge from start to finish. Problems arise when individuals do not feel free to communicate their ideas or try new things; however a clear chain of command helps to keep productivity high when the person in charge acts more like a productive facilitator. The second structure, Parallel Team/Exclusive Collaboration, is the most effective because it involves a division of tasks and expertise in which sub groups work separately but come back to the larger group to negotiate and collaborate. The third structure, Hybrid Team/Mutual Collaboration, suffers from a lack of productivity because it involves random subgroups working without a clear chain of command or task-related goal.

Table 4

Models for Collaborative Team Structures

Hierarchical Team/Dictator Collaboration Hierarchical Team (Chiu, 2002) – "Dictator Collaboration, in which participants decide who is in charge and that person leads the process" from start to finish (Maher in Kvan, 2000).	
Parallel Team/Exclusive Collaboration Parallel Team (Chiu, 2002) – "Exclusive Collaboration, in which participants 'work on separate parts of the problem, negotiating occasionally by asking advice of the others' (Maher in Kvan, 2000, pg. 413)." This type of structure is most effective and productive because people work in sub-groups becoming experts of sorts, and then report back to larger team	
Hybrid Team/Mutual Collaboration Hybrid Team (Chiu, 2002) – "Mutual Collaboration, in which participants are 'busy working together' (Maher in Kvan, 2000)." This type of structure often suffers from lack of productivity due to an unclear goal towards completing the task and unclear leadership.	

Note. Models for collaborative team structures, adapted from Chiu (2002) and Kvan's (2000) reference to Maher.

Collaborative design work flows: Actions that enable productivity. The collaborative team structure heavily influences the effectiveness of the collaborative design workflow, what Sawyer (2007) referred to as "blending egos" to keep "moving it forward." Based upon the leadership that is set in place, the level of productivity of the collaboration is affected by the ability to utilize group genius (Sawyer, 2007), communicate (Sonnenwald, 1996) and utilize resources (Sawyer & DeZutter, 2009; West & Hannafin, 2011), such as technology and other design materials.

Several researchers directly address the flow enabling actions characteristic of successful creative teams. Csikszentmihalyi (2008) researches the psychology of "flow," the ability to engage in effortless concentration that focuses attention and motivates action. Affected by a combination of high challenge levels, high skill level, and a clear set of realistic goals, this "flow" can prove to be very beneficial in a collaborative design situation. The Partnership for 21st Century Skills (2011), referred to as P21, identified skills within their framework that mirror Csikszentmihalyi's theories and are essentially an outline for how to enable flow in a classroom environment. In support of the effectiveness of the Parallel Team/Exclusive Collaboration structure, Sawyer's (2007) research on group collaboration and group genius identified the key characteristics of successful creative teams, which are indicative of how the underlying design thinking strategies take place within a successful collaborative design process (Table 4).

Technology tools for communication & collaboration in design. "Technology use in education has historically enabled new forms of communication and collaboration (Lomas, Burke, & Page, 2008)." These tools can allow members to collaborate with one another across boundaries of walls and even borders, through email, web-conferencing,

and digital file sharing systems. Along with that, these tools can also allow for more interactive and creative collaboration sessions, such as social networking and dynamic displays.

Technology tools for creativity in design: Digital fabrication. There are a profound number of design technologies on the market for commercial design as well as educational use. Amiel and Reeves (2008) stated that in education, "[t]echnology is much more than hardware. It is a process that involves the complex interactions of human, social, and cultural factors as well as the technical aspects" (p. 31). With that, one cannot evaluate the student experience of using a technology tool by simply assessing the final product which was made using it. Meaningful research necessitates that educators and researchers look at the process the student engages in with the technology in order to identify learning outcomes and potential benefits of its use. Because students cannot learn through simply consuming an educator's knowledge, they must actively create new knowledge and meaning for themselves (Dewey, 1938, Gagnon & Collay, 2001).

Digital fabrication is a hands-on process that uses technology to "make (almost) anything," effectively enabling everyday people to become equipped with the tools to make *what* they want, *when* they want, *all by themselves* (Gershenfeld, 2005, p. 4). It is the same process that is used in commercial and industrial design to create familiar items, such as cereal box product packaging and even the creation of cars from concept to full-scale reality. This same process can be achieved by students in the classroom thanks to the inexpensive costs of fabrication technologies, such as developmentally appropriate design software and personal fabrication machines (Berry, Bull, Browning, Thomas, Starkweather, & Aylor, 2010; Bull & Garofalo, 2009). The entry-level of the digital

fabrication process strives to present engineering opportunities that begin with personal fabrication machines that utilize subtractive techniques to trim 2-dimensional materials, such as thin media like paper, cardstock, and vinyl. Advanced levels of the process include the use of 3-dimensional "printing" machines that utilize additive techniques to build 3-dimensional objects out of malleable materials, such as silicone, frosting, and modeling clay. The entry level digital fabrication process (Figure 3) enables students to digitize ideas in developmentally appropriate design software, print the design on paper, trim and perforate the design on a personal fabrication machine, and finally assemble the design.

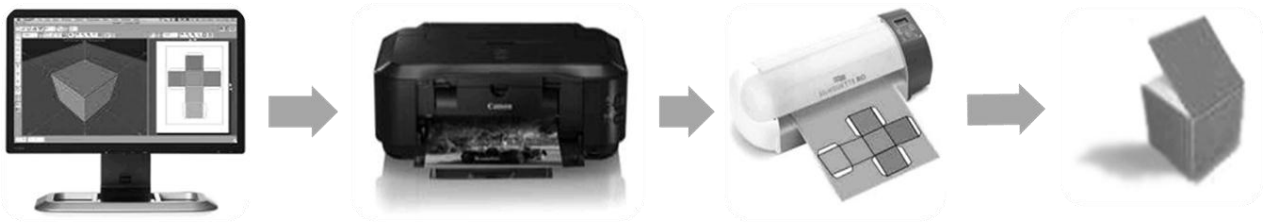


Figure 3. The digital fabrication process: 1) digitize, 2) print, 3) fabricate, 4) assemble.

Bull & Garofalo (2009) provide theoretical perspective on the educational implications of the digital fabrication process by noting that it has the potential to foster an engineering mindset and encourage the development of creative problem-solving skills in students of all ages with tangible hands-on activities that can reinforce curricular classroom concepts and skills. Accordingly, digital fabrication allows students to explore abstract visualization, software-based vectors, and hands-on geometric transformations, which are useful in design, mathematics, and many STEM-related fields (Eisenberg, 2011; McClurg, et al., 1997). Though packed with inherent interdisciplinary opportunities, this process also fosters creativity and means to explore alternative representations of personal meaning (Beyers, 2010; Hendrix, 2008). A process that until

recently was available only in commercial and industrial design is now accessible with entry-level concepts that allow students to go from 2-dimensional idea to 3-dimensional object, enabling them to become design manufacturers and engineers capable of multiple facets of construction.

Context of the CSTEM Creative Writing Challenge

This study is inspired by a previous case study conducted by the researcher which followed one middle school teacher's journey as she attempted to integrate the digital fabrication process to assist students with the creation of pop-up books in an afterschool program with an English language arts focus. The experience of collaboratively designing a pop-up book stimulated student motivation, addressed a variety of literacies, encouraged critical reflection, promoted peer interaction and social collaboration, allowed for design experimentation, and enhanced creativity (Smith, 2012).

In the 2012 CSTEM Creative Writing Challenge, students used digital fabrication to develop one pop-up book (a peer-level, illustrated, informational book that discusses the Dead Zone specific to their region). Collaborative bookmaking is an inherently creative task involving a great deal of problem-solving and design thinking. The problem-solving needed to complete this challenge is two-fold: 1) how to write a peer level informational book, and 2) how to illustrate the information with appropriate visuals and paper engineered elements that link verbal and visual literacy. In order to understand how participants will negotiate these challenges, a little background is necessary, including collaborative writing, pop-ups and paper engineering, and design technologies.

The writing process. In a series of children's bookmaking projects with a literacy focus, Johnson (1993) made note of the compelling magic that the book arts provide in an educational setting. He stated, "[t]he organization and development of ideas through the discipline of paginated sequence of writing and/or visual statements has produced some of the greatest achievements of civilization" (p. 10). Regardless of the genre that a writer is embarking on, there are six traits of effective writing, which include ideas, organization, voice, fluency, word choice, and conventions (Blasingame & Bushman, 2005). Simply put, ideas should be creative and informative. Organization should help the reader understand the information while the writer's voice should be apparent throughout the writing. Fluency should create flow and connect ideas while word choice should be appropriate for the reader. Lastly, proper conventions should be used to show a professional effort with regard to spelling, grammar, and punctuation. Adhering to these six traits enables writers to generate effective writing and also allows the effectiveness of writing to be judged (see 2012 CSTEM rubric example in Appendix A).

Similar to how designers engage in the design process to generate creative designs, writers engage in the writing process to generate effective writing (Vass, 2004). The writing process consists of five phases that include pre-write, draft, revise, proofread, and publish (Blanchard, 2011; Blasingame & Bushman, 2005). Comparable to the design process, the writing process also encourages reflection and acknowledges that the process is iterative (Figure 4).

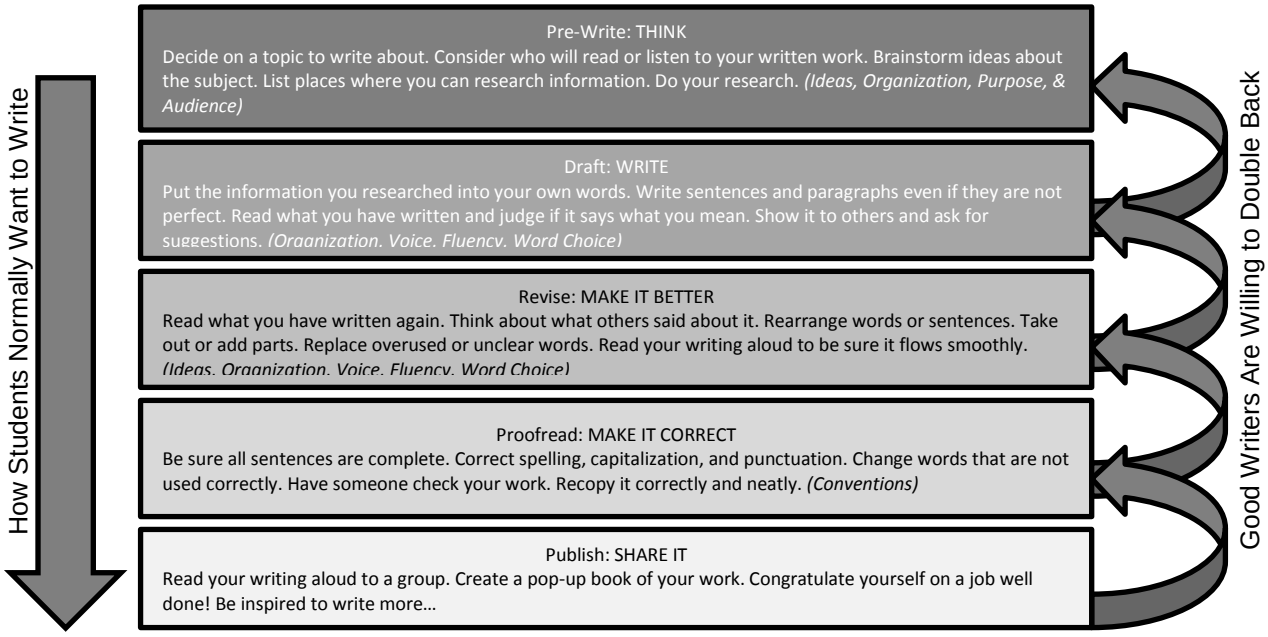


Figure 4. The writing process: 1) pre-write, 2) draft, 3) revise, 4) proofread, and 5) publish; adapted from Blanchard (2011).

Collaborative writing. Vass (2004) acknowledged that there is not much research on collaborative writing in PK-12 educational settings. Research findings within related studies maintain that writing completed in pairs or groups is more advanced than those completed by individuals because the social interaction may stimulate motivation and exploration, much like constructivist theorists claim as a fundamental principle in the formation of meaningful knowledge. Additionally, collaborative writing is a powerful exercise in teamwork where group negotiation can improve "quality, cooperation, critical thinking, peer learning and active participation toward an end product" (Hernandez, Hoeksema, Kelm, Jefferies, Lawrence, Lee, & Miller, 2010, p. 1).

Though there are clearly affordances, there are also disadvantages to using collaborative writing methods. Hernandez, et al. (2010) noted the issue of productivity within collaborative pairs and groups is an unfortunate reality with potential for choppy

writing or lack of individuality and personality. That said they also noted that potential disadvantages can be minimized if the educator uses purposeful strategies and evaluations in the classroom. In agreement with these unfortunate realities, Vass (2004) stated that socio-cultural analysis of student interaction and discourse can assist educators in making the most of the collaborative writing method. She went on to note that "in accord with current socio-cultural work on peer collaboration, the focus to the analysis of the *processes* of paired writing, through the examination of children's paired discourse" (p. 81). In essence, "with collaborative writing, the means to the end can be as meaningful as the end product itself" and the opportunity to authentically engage in meaningful processes can build "real-world social and professional skills" (Hernandez, et al., 2010, p.5).

Pop-ups & paper engineering. Pop-ups fall under the umbrella term "movable books," which is a subset of paper engineering. Movable books have a long history that began in 1250 A.D. with the creation of circular volvelles, which were initially used to teach astrological principles through the simple turn of the paper dial. Other interactive movable mechanisms such as gatefolds, pull-tabs, and eventually pop-ups, allowed for 3-dimensional explorations and interpretations of both fictional and non-fictional information (Abrahamson & Stewart, 1982; Hendrix, 2008). Pop-up books and other movables are inherently linked to language arts as they provide an engaging means to encourage reading and literacy. Not only can the opportunity to simply read or participate with a pop-up book engage and motivate students, but it can provide "unique stimuli for creative writing and original artwork" (Abrahamson & Stewart, 1982, p. 344).

As students begin to explore these interactive books further, they naturally begin to wonder how they are made and how they work, which necessitates visual-reasoning ability. Johnson (1992) describes this process of discovery by stating:

> The challenge is the often frustrating task of understanding how pop-ups 'pop-up' – for they seem far from logical at times – and the reward, the unparalleled pleasure and sense of achievement experienced when transforming a flat, folded piece of paper into a three-dimensional sculpture. It is in this momentary flowering, from passive horizontality to active verticality, that the desire to learn lies. (p. vii)

As the students embark upon creating their own functioning pop-ups, they take on the role of both author and paper engineering illustrator as they strive for a union between the visual and verbal forms of communication. This feat is indeed riddled with problem-solving and creative tasks as both are dependent upon one another and the combination unfolds a genuine lesson in literacy and creative expression (Abrahamson & Stewart, 1982; Shannon & Samuels, 1985). This progression allows students to explore design thinking strategies and methods to ideate and imaginatively construct ideas and "pictures of mind" (Olson, 1992) while also exploring how their pop-up mechanisms will function.

Digital video as a reflective ethnographic tool. Goldman's (2007) *perspectivity framework* provided a theoretical foundation for digital video to be used as a means to document cultural actions in "bits and segments" and transformed into "meaningful stories and valid results" (p. 15). Her synthesis of research acknowledged Perkins' (1986) view that engaging in design allows learners to experience real world success and come to understand their own knowledge, which is referred to as "knowledge by design"

(Goldman, 2007, p. 160). As Harel (1991) stated, “design motivates learning,” “designers make things happen,” “design evokes self-knowledge,” “designing a product promotes consideration of…the community of others that designers serve,” and “design is integrative and holistic” (p. xviii-xx). When students are able to create their own inquiry-based videos they engage a variety of modes (auditory and visual) and have the potential to showcase diverse perspectives (multiple participants with multiple views). Tobin and Hsueh (2007) stated that these videos can range from rough cut “raw” to “aesthetically pleasing, entertaining, compelling videos [which] are not just pleasing and entertaining – they also make for effective social science” (p. 77). They went on to state that these types of student-created videos strive to authentically promote self-reflection. In doing-so, the creation of these videos provides an opportunity for students to become the ethnographer, or the observing director behind the lens, who then communicates their view of their world, culture, and experience.

In the context of this study, students collaboratively produced reflective videos which allowed them to inquire and document the process used in the design and development of their peer-level creative non-fiction pop-up books. The use of student reflective videos exemplified constructivist, student-centered learning which Harel (1991) indicated can allow student learners to be put “in the role of media producers rather than consumers,” which effectively encourages the student to “think about thinking” (p. 6).

Summary of the Literature

In summary, the related literature explored constructivism as a foundation for structuring project-based learning experiences that allow students the opportunity to

engage in creativity and collaboration. Creative skills and design thinking habits of mind were discussed as characteristics that have potential to be fostered through experience and practice. Collaborative design processes were explored to show that there are numerous methods to be used and that they are dependent upon the diversity of the group and the task at hand. Collaborative design structures, work flows, and tools were explored to show the additional variables which affect the design process and the ultimate finished product. Lastly, the context of the experience under study was explored to provide adequate background into the fundamental themes of the challenge itself, including student-created reflective videos. The creation of similar videos allowed the students to not only foster further ownership and creativity within the project itself, but also allowed the students to walk alongside the ethnographic researcher to document the experience as it unfolded.

Chapter III

Methodology

Using ethnographic methods, this exploratory study weaves narratives of PK-12 student participant experiences as they engaged in collaborative design throughout the CSTEM Creative Writing Challenge. As Eisner (1991) stated, qualitative research is used to uncover qualities related to particular individuals who are engaged in particular experiences. Ethnography was chosen in order to capture a holistic cultural portrait of the experience from the student's own perspective. Fetterman (1998) extended an understanding of ethnography as he stated:

> The ethnographer is interested in understanding and describing a social and cultural scene from the emic, or insider's perspective. The ethnographer is both storyteller and scientist; the closer the reader of an ethnography comes to understanding the native's point of view, the better the story and the better the science. (p. 2)

The resulting naturalistic inquiry may provide transferability (Lincoln & Guba, 1985; Rudestam & Newton, 2007, p. 112-13) of a potential framework for PK-12 teachers who wish to engage in similar collaborative design experiences with their own students. The purpose of this study is not to prescribe a *defined design process* for the students to engage in, but rather to uncover the experience of the collaborative design process and the relationship between process and product through narrative examples of diverse participant teams in the 2012 CSTEM Creative Writing Challenge.

Participants and Sampling

This study included approximately 200 PK-12 students who participated in the *2012 CSTEM Creative Writing Challenge*. Students participated as part of feeder pattern teams, with each team consisting of one elementary group, one middle school group, and one high school group. The feeder pattern teams worked collaboratively to complete the challenge, which was then presented and displayed at the annual competition. All teams were invited to participate in the study; however, participation was not required. The 2012 challenge involved a total of 11 feeder pattern teams, which were from a variety of geographic locations, including two teams from San Cristobal, Dominican Republic, one team from Memphis, Tennessee, one team from Bladensberg, Maryland, and seven teams from Houston, Texas. Teams received the challenge criteria on November 5, 2011 and turned in their completed products at the annual competition in Houston on March 31, 2012.

CSTEM Curriculum Development

CSTEM works with industry experts that are connected with current issues that affect the environment. These experts present this information to the CSTEM Team during planning and development and then the overall theme is decided. With a theme in place, the CSTEM Team members, including curriculum developers and teacher trainers such as the researcher, collaboratively build curriculum that connects all challenge areas, including challenge descriptions, procedures, materials lists, training sessions, and assessments. Curriculum decisions are informed by feedback from former participant teachers and students. The 2012 CSTEM Challenge theme focused on the “Sea Turtle” and the “Dead Zone” because both are current topics in environmental science which

industry experts have identified as important. Located in various regions around the world, "Dead Zones" are marine areas suffering from *hypoxia,* or a reduction of oxygen levels in water to the point that animal life cannot be sustained (National Oceanic and Atmospheric Administration [NOAA], 2011; US Environmental Protection Agency [EPA], 2012; Bruckner, 2011). Given the impact of the April 2010 BP oil disaster in the Gulf of Mexico, these themes were natural choices for inclusion in the 2012 Challenge.

Data Sources

Data was composed of a variety of sources including product quality ratings (rubric), reflective videos, and a focus group interview (Table 5). The data was analyzed to cross-check and corroborate information by including opportunities for collaborative group responses and individual responses.

Table 5

How the Data Will Support the Findings

Data Source	Who Will Collect Data, and How?	Who Will Analyze Data?	How Will Data Be Analyzed?	How Will Data Answer Research Questions?
Product Quality Ratings (Rubric)	Researcher collected paper copies of the judges scored rubrics at the competition on March 31, 2012.	Researcher, Peer Debriefers, External Auditor	Rubric scores were entered into a spreadsheet and tallies were created for each criteria area. Scores were ranked from first through eleventh place.	Question 2
Reflective Videos	Researcher collected digital copies of the videos at the competition on March 31, 2012.	Researcher, Judges, Peer Debriefers, External Auditor	Videos were transcribed and analyzed for verbal and visual meaning using content analysis. Coding themes were created according to themes that emerged from the videos.	Question 1, Question 2
Focus Group Interview	Researcher completed the focus group interview as part of program evaluation at the CSTEM competition on March 31, 2012 at the George R. Brown Convention Center.	Researcher, Peer Debriefers, External Auditor	Interview was semistructured and retrospective. It was audio recorded, transcribed, and used to compare information from the reflective videos. Additional coding themes were generated as needed.	Question 1, Question 2

Product quality ratings (Rubric). An analytic 15-item rubric (Appendix B) was used at the 2012 CSTEM Challenge to assess the completed pop-up book design (including the overall bookmaking design and paper engineered illustrations within it), use of the six traits of writing, and the reflective video (including the technical structure of the video, depth of student reflection on concepts and design process, demonstration of completed pop-up book, acknowledgement of the community impact, and overall communication). Learning from past challenges, the researcher designed the rubric to be more detailed in order to provide clearer criteria to support objective measurement. Past rubrics did not equally weigh the writing with the illustrations of the book; therefore, the creative writing appeared less valuable. The 2012 rubric contained four criteria that measured the pop-up book design, six criteria that measured the six traits of writing, and five criteria that measured the reflective video.

The CSTEM judges were volunteers from sponsor and partner organizations throughout the Houston-metropolitan area, including educators, business professionals, and scientists. Volunteer judges were compensated with professional development credit hours in exchange for committing to work six hours at the annual competition. The rubric was tested for validity during the two-hour training session scheduled with the volunteer judges during the week of March 25, 2012. The training included a focus group activity in which clarification of subjective wording reached a consensus as well as a modeling activity to demonstrate the scoring of a pop-up book entry from the 2011 CSTEM Creative Writing Challenge.

The scores were ranked from first place (1) to last place (11) to determine the winning team for the CSTEM Creative Writing Challenge and were also used as a

comparison between the evaluation of the process to determine if a relationship between process and product is significant (see *Wilcoxon Signed-Rank Test* section below).

Reflective videos. Upon finalizing the pop-up books, each team collaborated to create a reflective video that chronicled the design process they used as well as demonstrated the completed pop-up book according to the following criteria:

> Students will collaboratively create one reflective video for the entire feeder pattern team that showcases the creation of their pop-up book. The feeder pattern team must work collaboratively to construct a video that documents the work process of the project, demonstrates how to read and interact with their completed pop-up book, and addresses the impact their pop-up book will have on the school community and the community at large. The video should be formatted as student interviews explaining methods and processes used in the creation of their pop-up book, include examples from the process (photographs or video sequences), and reflect upon the collaborative experience. The video should not exceed 4 minutes. (Appendix A)

The criteria for the reflective video were developed after meetings between the researcher and other CSTEM colleagues to reflect on the 2011 Creative Writing Challenge. It was determined that the lack of interaction with the students and the judges resulted in the judges being confused about how to interact with the pop-up books and ultimately made it difficult to accurately score the final products. One 2011 judge in particular had mentioned to the researcher how great it would have been to have had the opportunity to interview the students so she could hear how they made the pop-up book and how they intended for the reader to interact with it. This served as the inspiration to

explore reflective video as a means for the students to self-report on their process and provide the judges, as well as fellow competitors with a virtual interview to share their experience. In this manner, reflective video is "a multimodal text to express ideas and connect with an audience" (Bell & Bull, 2010). (For an example of the full 2012 Creative Writing Challenge Description that participants received, see Appendix A.)

As previous research indicates "[t]he reflective and active nature of filmmaking spawn[s] a cycle of learning: the action resulting in deeper reflection and the reflection resulting in praxis—a set of deliberate and informed student actions" (Southwest Educational Development Laboratory [SEDL], 2000, p. 8). By getting involved in the design process and culminating the experience with reflective video, students in the 2012 Creative Writing Challenge engaged in critical thinking resulting in a reflective experience. Student-created video was used as a performance based assessment not only to provide an account of their thinking and experience throughout the collaborative design process, but also as a means of virtually demonstrating to the judges how their final pop-up book artifact was intended to be read through and interacted with.

Student-created reflective videos were analyzed using content analysis because it is a method that allows ethnographers to test for internal consistency (Fetterman, 1998, p. 102). In doing so, the researcher was able to identify the *manifest content*, or "obvious, surface content" and the *latent content*, or "the meaning underlying what is said or shown" (Frankel & Wallen, 2009, p. 477). Utilizing Heider's (2006) *Attribute Dimensions of Ethnographic Video*, the researcher was able to assess the reflective videos as an ethnographic *demonstration of the process* (Table 6). The resulting rubric scores

were later compared with the Judges' product quality ratings, which will be discussed in the *Wilcoxon Signed-Rank Test* section below.

Table 6

Heider's (2006) Attribute Dimensions of Ethnographic Video (p. 16)

CRITERIA	1	2	3
Ethnographic Basis (of student inquiry)	uninformed by ethnography	fairly informed	deeply shaped by ethnographic understanding
Relation to Printed Materials (pop-up book)	no printed materials	fairly well supported by printed materials	fully integrated with printed materials
Whole Acts	fragmentary bits of acts	some whole acts	beginning, peaks, and ends of acts
Whole Bodies	excessive fragmented close-ups	some whole bodies	maximally necessary whole bodies
Explanation and Evaluation of Various Distortions	no acknowledgement in film or in print	some attempt	fully adequate
Basic Technical Competence	distracting incompetency	reasonable competency	exceptional quality
Appropriateness of Sound	inappropriate	moderate narration	natural synchronous sound
Narration Fit	redundant overly wordy, unrelated	narration relates fairly well	originally demystifying and relevant to visuals
Ethnographic Presence	ethnographer's presence ignored by film	ethnographer's presence mentioned	ethnographer shown interacting and gathering data
Contextualization	isolated behavior shown out of context	gestures toward contextualization	well contextualized
Whole People	only faceless masses	some attempt to represent the people	develops feeling for an individual
Time Distortion	temporal sequences rearranged	condensed time	real time
Continuity Distortion	single sequences constructed out of shots from many actual events	some attempt to show actual sequences	actual sequences preserved
Inadvertent Distortion of Behavior	extreme	moderate	minimal
Intentional Distortion of Behavior	extreme	moderate	minimal

Note. This rubric originally contained only nine levels of performance that were weighted in the middle. It was modified to provide three scoring options for each criJudges'terion (shown in gray).

The reflective videos were transcribed, analyzed, and "divided up into meaningful units (segmented and categorized)" (Gray & Malins, 2004, p. 133). By thoroughly comparing and contrasting the narratives from the teams, relevant themes were identified and explored to attempt to answer the research questions.

Focus group interview. In ideal situations, ethnography includes extensive observation in natural social settings; however, when access to such opportunities is restricted the researcher uses focus group interviews to simulate interactive, informal discussions to "facilitate participant observation-like understandings" (Stuter, 2000, p. 1). The focus group interview for this study was completed at the culminating competition in March, after the teams finished the pop-up book artifact and the collaborative video. The focus group consisted of one volunteer student representative from each of the 11 teams, who was willing to participate. The interview lasted approximately 60 minutes and was a semistructured, retrospective format, which consisted of a combination of survey questions, detail questions, and open-ended questions (Fetterman, 1998). These questions (Table 7) were used to further develop a holistic cultural portrait to identify construct definitions and clarify themes that were important to understanding the collaborative design experience of these students, which included structure (roles, leadership, and sites), processes (design thinking and the specific steps used to collaboratively design), and workflows (communication, technology used to communication and collaborate, technology used to design, roadblocks and hindrances). Results from the focus group interview were used to provide another emic perspective to be woven throughout the narrative of the student experiences in the collaborative design process.

Table 7

Focus Group Interview Questions

Themes to Explore	Questions
Process	1. What process did you use to design and develop your pop-up book? 2. What was the sequence of activities? Discuss them in in the order that they took place. 3. How long did the process take? (From idea to finished product) 4. Did you have to start over or redo something? Why?
Workflow	5. How many different concepts/ideas did you have and how did you narrow them down to one concept/idea? 6. What problems did you encounter and how did you solve them? 7. What would you do differently next time?
Structure	8. Who did which tasks (roles) and why? 9. Who determined the roles? 10. Where did your team work on the Creative Writing Challenge?
Miscellaneous	11. What do you think is the best part of your design? Why? 12. What impact will your pop-up book will have on the school community and the community at large? 13. How does the pop-up book reflect your_____ skills? (Storytelling/ Engineering/ Critical thinking/Problem-Solving/Writing/Design/Creativity

The Evolution of Coding to Promote Validity

It is acknowledged that "coding is heuristic-–an exploratory problem-solving technique without specific formulas to follow" (Saldana, 2011, p. 8). Much like the design process, the coding process is iterative. Coding involves more than merely labeling: it involves the continuous generation of relationships between words in order to identify deeper meaning. Once all of the data had been collected and transcribed the researcher began a first cycle analysis using the "comment" feature to highlight sections within the Microsoft Word application, to effectively split the data into individually coded segments. Beginning with elemental methods of *initial codes* and *process codes,* the researcher searched for instances that aligned with the basic themes identified within

the previous literature, including structure (roles, leadership, and sites), processes (design thinking and the specific steps used to collaboratively design), and workflows (communication, technology used to communication and collaborate, technology used to design, roadblocks and hindrances). Using other techniques suggested by Saldana (2011), the researcher continued first cycle analysis by using *In Vivo codes*, or direct quotations from the participants, to begin exploration of the underlying themes beyond the surface level analysis, which resulted in the emergence of other themes (Table 8). In Vivo codes proved to be effective in this instance because of the ability to "honor children's voices and to ground the analysis from their perspective" (Saldana, 2011, p. 48).

Table 8

First Cycle Codes

Initial Codes and Process Codes	Structure • Roles • Leadership • Sites • Team	Process • Design Thinking • Specific Steps • Brainstorming • Creativity	Workflow • Communication • Technology • Roadblocks and Problems
In Vivo Codes	Team Structure • A group of one • "Staying on task" • "Being part of a team" Self-Awareness • "My future" • "Helping others" • Confidence • "Inform the community" • "Help nature"	Learning Process • "Anything that you're going to do involves words" • Multiple literacies Design Process • "Brings it to life" • Resourcefulness • Problem-solving • Critical-thinking	Work Ethic • "Troublemakers" • "It makes no sense to waste time" • "You can't control anybody but yourself" • Realities of group work • "Chose people who are good for you"

Collaborative research with peer-debriefers. In addition to the analysis conducted by the researcher, two peer debriefers independently reviewed the data and were asked to identify major codes (themes and patterns) on their own. As a research team the rationale and progress of the analysis, including the evolving codes and patterns,

were compared to measure reliability in order to provide further credibility to the study. The first peer-debriefer, Emily, was a doctoral candidate in Curriculum and Instruction with an emphasis in Instructional Technology. Her extensive background in teaching secondary-level language arts in low-SES schools coupled with her research interest in student engagement influenced the codes and themes that she identified throughout the data. The second peer-debriefer, Juliet, was a recent Ed.D. graduate in Curriculum and Instruction with an emphasis in Teacher Education. Her background in teaching early childhood and theatre arts together with her research interest in creativity and arts advocacy also influenced the lens through which she viewed the data.

Through discussion, the research team identified if the discrepancies in theme selection were due to variances in construct definitions or if one researcher noticed something that the others had not. Primary discrepancies included the researcher including codes for "writing process" within the code for "process," whereas Emily separated them as their own process. It was agreed that they could both be coded as "process" because of the context of the creative writing challenge; though Emily agreed that they could be reemphasized as components of "multiple literacies." Juliet noted a discrepancy in the definition of "collaboration." As seen in the previous literature, the researcher defined collaboration as effectively working together to design a shared product. Collaboration can vary in intensity whether teams share every aspect of every task or merely consult and negotiate with one another at various stages of the process. Juliet acknowledged this defining construct of collaboration and suggested that perhaps future research could explore that specific component more deeply to further clarify it within the context of PK-12 education. Once a consensus was reached, the analysis was

summarized onto a one page document. To provide confirmability (internal validity), the analysis was reviewed by an external auditor (outside expert) who was qualified to ensure that the analysis is empirically grounded (Carspecken, 1995; Rudestam & Newton, 2007).

Final evolution of codes. Based upon the perspectives brought forth by Emily and Juliet, second cycle coding methods utilized *pattern codes* and *focused codes* in order to synthesize the codes into meaningful themes for discussion (Table 9).

Table 9

Second Cycle Codes

Process	Multiple Literacies	Altruism	Life Lessons	Process & Product
• Diverse people and methods • Researching and brainstorming • Decision-making and collaboration • Critical-thinking and problem-solving	• The words of verbal literacy • The images of visual literacy • The interactions of scientific environmental literacy	• A desire to "inform the community" • A desire to "teach others"	• Creativity • Collaboration	• Judges' product rubric scores • Researcher's process rubric scores

Wilcoxon Signed-Rank Test

To make an inference about the relationship between the collaborative design process and the effectiveness of the product the Wilcoxon Signed-Rank Test was used. This inferential statistical method uses nonparametric techniques to analyze small sample sizes by calculating the difference between two sets of ranked data (Frankel & Wallen, 2009).

In order to answer the second research question (What is the relationship between the design processes used and the effectiveness of the final products?), the researcher utilized the rubric scores from the judge's perception of the *product*, as seen in the rubric scores that included the pop-up book, the writing, and the reflective video; in comparison to the researcher's perception of the *process*, as seen in the rubric scores that included

Heider's (2006) *Attribute Dimensions of Ethnographic Video* to assess the reflective videos as an ethnographic demonstration of the process.

Chapter IV

Results

The focus of this study was two-fold: 1) to identify the various processes that the teams used in order to complete their collaborative pop-up books in the 2012 CSTEM Creative Writing Challenge and 2) to explore the relationship between process and product. To satisfy the first area of focus, the design process was explored through a synthesis of student-created reflective videos and one focus group interview which resulted in the following major themes: process, multiple literacies, altruism, and life lessons. The second area of focus was addressed through the notion of effective design by exploring the relationship between process and product. This relationship inquiry included analysis of the Judges' rubrics and the researcher's own analysis of process as seen in the reflective videos, which considered the students as ethnographers of their own design experience and used Heider's (2006) *Attribute Dimensions of Ethnographic Video*.

The results are presented in the following sequence not only to address the two research questions but also to show the progression (or learning process) that the student participants actually went through. They began by engaging in a collaborative design process within which they identified multiple literacies, expressed altruistic statements about a desire to save the planet, and then ultimately reflected on the life lessons learned through the experience. The presentation of results culminates with the rubric assessments from the judges' view of the product and the researcher's view of the process upon the completion of the 2012 CSTEM Creative Writing Challenge.

Process: Diverse People and Diverse Methods

Through working with a diverse group of peers, students were exposed to a variety of ages, skills, and previous experiential knowledge. Much of the previous literature maintained that it is this sense of diversity which enables collaborative creativity to thrive (Grefe, 2010; Sawyer & DeZutter, 2009; Smith & MacGregor, 1992; West & Hannifin, 2011). Most teams functioned effectively in *parallel structures with exclusive collaboration* and experienced a great deal of productive collaboration, while others functioned ineffectively in *hybrid structures with mutual collaboration* and experienced a lack of productivity due to unclear leadership (Chiu, 2002; Kvan, 2000).

As seen in the literature, there are a variety of design processes that teams can use to complete their task (Findeli, 2001; Lawson, 1990; Rayala, 2011; Sawyer & DeZutter, 2009; West & Hannifin, 2011). The teams that competed in the 2012 CSTEM Creative Writing Challenge were proof of that variation as they each exhibited different processes, structures, and workflows. However diverse the specific phases of their process were, the researcher's first hypothesis was correct in that the teams shared similarities of process which included three methods, 1) researching and brainstorming, 2) decision-making and collaboration, and 3) critical thinking and problem-solving.

Researching and brainstorming. Inquiry is vital to the learning cycle as learners conduct research to uncover more about topics of interest and creatively brainstorm about ways in which they can demonstrate and/or utilize the new knowledge. "My favorite part was using, I mean, looking up research because I learned many new things" (Girl D, Team 11 video, line 5). Surprisingly, many students commented that they enjoyed researching information for the challenge, which was to create a peer level

creative non-fiction pop-up book that explained the "dead zone" in relation to their local community and region. With the facilitation of their teachers, students embarked on "rituals of preparation" (Tharp, 2003), or fact finding missions, to uncover as much information as they could about the topic. "We first went on to the Internet and researched about the dead zone. And then we wrote the story and picked facts from what we [found]" (Girl A, Team 11 video, line 2). The research that the students discovered was then incorporated into their creative ideas, effectively transforming the research into creative non-fiction, or "facts with flair."

Students enjoyed brainstorming and coming up with creative ideas that could make the factual information appealing to their peers. Some even likened it to making a textbook that students would *actually want to read*. Jacob, for example, enjoyed drawing inspiration from familiar stories such as "Finding Nemo" and said, "I liked coming up with the ideas and trying to connect it" (Focus group interview, March 31, 2012). Jacob's ability to draw inspiration from familiar stories in popular culture expresses his ability to articulate "integrative thinking" (Brown, 2008) and to "make novel combinations" (Michalko, 2001).

Decision-making and collaboration. Literature on creativity and design-thinking clearly indicated that the ability to efficiently make judgments and effectively collaborate with others are essential to the success of any project. The students in this study took control of the process every step of the way by making decisions on how their product would be crafted. "We started out by finding the main question of our pop-up book. We separated it into ten main questions then we narrowed it down to three main questions and we started to explore them to write the story" (Boy A, Team 11 video, line

8). This example of team cooperation is similar to Chiu's (2002) process model which includes iterative cycles of negotiation, decision-making, and consultation.

Critical thinking and problem-solving. One of the key components of critical thinking and problem-solving is the ability to be creatively resourceful. Regardless of the method employed, critical thinkers identify the problem and develop a solution to overcome it using creative habits of mind (Brown, 2008; Michalko, 2001; Root-Bernstein, R. & Root-Bernstein, M., 1999; Tharp, 2003). Through *CSTEMbreak*, the non-profit organization's private social media community, students were able to identify and use resources by networking with one another and asking for support when problems arose throughout the process. As seen in the reflective videos, teams were able to identify and use a variety of creative tools to complete their pop-up books, including 2-dimensional personal digital fabrication machines and digital design software.

Surprisingly, many students made note of how important it was to be resourceful to identify and recruit teammates who possessed valuable skills. Serena noted this as she stated, "I notice the people who work hard and are good at their jobs. You might not know that person but you see how hard they work and they like the way that you work, so we could be great partners" (Focus group interview, line 80). The collaborative design experience not only allowed students to identify teammates with desirable work ethic and talent (Brown, 2008), but also serendipitously foster friendship among the teammates:

> "The partner that I worked with, I had never gotten to know her before and now we are like the best of friends and we're always talking. This [experience] made me choose my friends a little better, so that life [lesson] is good" (Jackie, Focus group interview, line 79).

Multiple Literacies

Seeing the connections between multiple experiences and multiple content areas is not only a foundation of constructivism (Dewey, 1938; Gagnon & Collay, 2001; Piaget & Inhelder, 1969) but it is also a foundation of design thinking (Brown, 2008; Michalko, 2001; Root-Bernstein, R. & Root-Bernstein, M., 1999; Sonnenwald, 1996; Tharp, 2003). Embracing this vision requires multiple literacies, which in the context of this study involves verbal, visual, and scientific environmental literacy. Student participants build rich learning experiences by engaging these literacies through activities that authentically correlate to national standards (CSTEM website, 2012).

The words of verbal literacy. Serena poignantly summarizes how engaging in the collaborative design process allowed her to experience a variety of valuable things. Through acknowledging her multidisciplinary accomplishments in relation to how it can help her achieve her prospective goals to pursue engineering, Serena stated,

> "As I get older I see how important it is to do these types of things. Being able to communicate and write is going to help me with my future. I've never helped make a book before! I look at that and I'm like, wow! I can't believe I did that. If I keep working on communicating and writing then I can be so good at this in my future" (Focus group interview, line 74).

Many students acknowledged their engagement in the writing process and the many aspects of creativity and design within verbal communication. Drafting and story development was one skill area that students acknowledged improvement in. Jacob noted that, "it taught me how to visualize and make the characters have more conversations together." (Focus group interview, line 76). When asked why he wanted to use a

conversational narrative in his creative non-fiction writing he explained, "to help the story make more sense and for there to be more creativity in the book. The conversations also helped to transition to other things to help explain things better" (Jacob, Focus group interview, line 78).

The images of visual literacy. As Jackie eloquently defined it, the visual components of the project allowed the words to come to life (Focus group interview, line 26). But this goes beyond the clichéd phrase that "a picture is worth a thousand words." Visual literacy allows students to meaningfully make connections across modes and also reinforces creative habits of mind such as critical-thinking and problem-solving. Many of the teams utilized complex visual supplements in their final projects including hidden doors and movable charts to further explain information to the reader.

> "On this page we have hidden windows (demonstrates how to lift the flaps of the large picture to unveil the picture inside). When you open both sides the picture shows you how algae is transformed into gas you can put in your car (closes the flaps)" (Boy D, Team 11 video, line 21).

The interactions of scientific environmental literacy. Science and the environment were deeply rooted in the challenge from beginning to end as teams were assigned to research and inquire about the "dead zone" phenomenon. By exploring the environmental topic of the "dead zone" and the biological effects it has on living organisms such as the sea turtles, students were able to fully explore facts and propose actual solutions. Their increased exposure to the topic enabled them to become immersed in a world that they did not know much about. To their surprise, the formerly unknown topic was intertwined within their local community.

"When I first started off, I didn't know what the dead zone was at all. No knowledge what so ever (shakes head). And now, I know a lot about it. I know that it's caused by algae and nitrogen and that we can do a lot to stop it, like stop using so much corn" (Girl F, Team 11 video, line 16). This honest reflection of learning about the "dead zone" was echoed by many students who expressed surprise when they learned of the everyday common causes and the fact that there are hundreds spread around the world, the Gulf of Mexico being the most notorious. What was at first a foreign concept to grasp became *more real* throughout the project-based learning experience. "Being able to write about, draw about it, it helped make it more real. And you can't have science without the words, without the stories" (Serena, focus group interview, line 85).

Altruism

Upon completion of most project-based learning assignments that deal with the environment, students tend to feel a genuine desire to reverse the damage that human consumption has caused on the earth. As such, students tend to make many altruistic comments about being on "a mission to change the world" (Jackie, Focus group interview, line 89). However, the opportunity to inquire into the impact that "dead zones" have on their own communities allowed student participants to personally empathize with the situation. Empathy is not only a great characteristic to possess, but Brown (2008) identifies it as a creative habit of mind.

A desire to "inform the community" and "teach others." Moving beyond the personal statements of wanting to save the planet, students articulated a desire to inform their community and teach others in order to create *real* action. Most of these sentiments were woven within the creative non-fiction writing of the collaborative books; however,

poignant statements were interjected throughout the reflective videos. Some noted specific topics to address in which one boy stated simply, “I hope this book shows the community the importance of not polluting our water” (Boy B, Team 10 video, line 4). Another student, playing the role of a teacher in front of a class, emphatically exclaimed, “we have to reduce carbon dioxide to save our planet and save the sea turtles” (Female Student “Teacher,” Team 7 video, line 41). On a more philosophical level, another student emotionally stated that,

> “We always talk about ourselves just as human beings and we set ourselves above the other living things. But we forget that our actions have serious consequences and that our home also belongs to the other living things” (Girl B, Team 8 video, line 9).

Regardless of the level of passionate statements, there was much agreement among teams that they had high hopes for their book to be used to inform and teach children within their school community. “Hopefully this book will inform the community about how it is important to keep the Earth clean so the turtles can stay alive” (Girl B, Team 10 video, line 3). In agreement, another student stated, “I certainly hope that we can donate this book to the library for the younger generation so that as they grow up they can learn to use this book to raise awareness to the problem” (Boy C, Team 11 video, line 18).

Life Lessons in Creativity, Collaboration, and Work Ethic

Amid all of the aforementioned themes, there was still a need to take a closer look at the overall culture of the participants in the study. Though the researcher embarked upon the journey with specific goals in mind, one could not help but see the important

life lessons that bubbled to the surface, as heard through the voices of three student participants.

Jacob the elementary school idea guy. Jacob, a third grade student at a low SES elementary school joyfully joined the *CSTEM Challenge* team at his school. Because of his love for stories, he decided to focus on being a part of the *Creative Writing* group. He was looking forward to getting to make a book and spending more time with his peers. With a noticeable stutter but a head full of thoughts and questions, he has found it difficult to interact socially outside of the regular classroom. The STEM-based *Creative Writing* bookmaking project allowed him to be a popular choice to work with on this collaborative project given his "smarts."

Creative thinking. Generating ideas came easily to Jacob and he enjoyed working with others. Once ideas were chosen for further exploration, he also found it easy to research facts to include in the collaborative book. Jacob knew where to look to find out information, how to take notes, and he knew how to organize the information for the rough draft. Within his peer group his ideas were validated during brainstorming sessions and his ability to connect the pieces of the puzzle made him a valuable group member. Jacob and his team used inspiration from familiar things as a model for their writing and illustrations. The ability to work in this manner was engaging and motivating for young Jacob as he continued to collaborate with his group.

A group of one…all on his own. As the CSTEM challenge continued throughout the year, some of Jacob's *CSTEM Challenge* teammates were unable to continue working on the various challenges in the afterschool setting because of time conflicts and/or moving to other communities. Because of this realistic setback, some of his *Creative*

Writing group members were needed to fill the spots in the other groups so that the school's team could continue to participate in the year-long *CSTEM Challenge*. "At first there were 3 people, but then one left and then the other one had to go do the Green challenge. So that left me doing most of it from my school" (Focus group interview, March 31, 2012). Luckily, his teacher stepped in to assist him with realizing his ideas that he had originally brainstormed with his group members. Jacob enjoyed being a part of the writing process because he "liked starting the rough draft off" and eventually seeing it in the final copy form. With the support of his teacher, Jacob was able to overcome the challenges of being "short-handed" and created a respectable product inspired by his ideas and personal creativity.

Jackie the middle school serious creative. Jackie, a seventh grade student at a low-SES middle school joined the *CSTEM Creative Writing Challenge* team at her school because she wanted to continue her passion for art. "I got into it because I like art. I really liked making the pop-ups because I like origami" (Focus group interview, March 31, 2012). The group decided to split the tasks in half with one half of the group being tasked to write the story and the other half being tasked to create the illustrations and pop-ups for the writing. As one of the group's most promising artists, Jackie enjoyed the opportunity to "hear what their vision was and then bring it to life" (Focus group interview, March 31, 2012).

Connecting art and CSTEM. Attempting to broaden her experiences, Jackie was intrigued to learn more about the scientific concepts that were the focus of the *CSTEM Creative Writing Challenge*. Though a good student at school, the opportunity to bridge art and science proved to be a fulfilling experience for Jackie.

> "For me, it was a great learning experience because I had never thought about all of this stuff. I didn't know anything about the sea turtles and their environment or how the oil spill and other pollution affected them. They were so hurt and I felt so bad (animated tone to express emotion). It really made me look at what I need to change to help nature. I learned that there are programs that I can enter to help out. Really, I guess you can call it a mission (sounds more like a question). A mission to change the world. So…(smiles)" (Focus group interview, March 31, 2012).

"It makes no sense to waste time." Yearning to find inspiring opportunities with serious peers, Jackie joined the team to see if she could find a place where she felt that she fit in:

> "I have to be honest, most of the people in my school are very childish. They kind of act a fool and don't take anything seriously. I want to work with serious people. People who know that they want to get it done, figure out how they are going to get it done. Because I really do not like wasting time. I feel like that is useless. You only have one time to do something. Time is very limited, so you can't waste it because you only have one life to live. It makes no sense to waste time" (Focus group interview, March 31, 2012).

Even though Jackie still encountered the occasional "trouble maker" or "people who acted a fool," she continued to do her part and learn as much as she could from the experience. This dedication to real life lessons proved to show that Jackie was wise beyond her years and that the experience of engaging in the *CSTEM Creative Writing Challenge* offered her more than just an opportunity to explore art and science: it allowed

her to explore personal awareness and real world work ethic. “For me it helped me to learn how to work with the right people. I was actually surprised by the people who acted a fool. I was like ‘why are you sitting there’” (Focus group interview, March 31, 2012)? Jackie continued later in the interview to express how her observations of fellow team members allowed her to reevaluate her own friends:

> You gotta be strong and choose people who are good for you. I learned that from some of the people that I thought were my friends . . . they laughed at me when they saw me doing all of this work, “aw, you’re a goodie goodie because you do all of your work in class, blah, blah, blah”. And uh, it taught me that I have limited time in school so I can choose people who will help me or people who will hurt me. (Focus group interview, March 31, 2012)

Serena the high school communicative leader. Aspiring to be an engineer, Serena, a tenth grade student at an urban science magnet high school, joined the *CSTEM Creative Writing Challenge* team at her school because she saw it as an opportunity to increase her communication skills. “And it’s like my momma always tells me, there is going to be a lot of writing no matter what you do.” (Focus group interview, March 31, 2012, line 2). Though she initially did not identify herself as an artist or even as a creative individual, she took on the challenge because it was important to her to continue to grow and enhance her skillsets for her promising future. “I got better at writing, creating, and drawing. It helps me see that if I keep doing this it will help me in the future. If I keep being able to communicate with people well, I will be better off later” (Focus group interview, March 31, 2012).

"You can't control anybody but yourself." Much like Jacob and Jackie, Serena learned firsthand the importance of a good work ethic and acknowledged its importance in school and the real world. Communication and collaboration were characteristics that Jackie felt were incredibly important for both herself and her peers to possess.

> My engineering teacher. He'll always put us in groups for projects and assignments. We're like, "uh, group work again" and he says, "yes because that's how it is in real life." He always says, "in life you're going to have to work with other people, so just get ready for it." (Focus group interview, March 31, 2012)

The logic of group work and the value of being able to collaborate with others came easily to Serena. Because of her seemingly logical perspective, much like Jackie, Serena struggled to understand why other teammates did not view it the same way. "I mean, this is your job just like in the real world. It's going to constantly be a job. I mean if you can't control yourself or focus on the task then you're going to have problems in life" (Focus group interview, March 31, 2012). Serena adds to that sentiment by sharing that lacking self-control eventually wastes the energy of others because:

> If you don't communicate in class when there is time to actually work on it and then you want to go home and text or email I don't see how that is going to get the work done. I think it's laziness if you don't actually use the time that you are given in class. That's just a waste of everyone's energy. (Focus group interview, March 31, 2012)

Her realistic perspective coupled with her ability to observe others' skills and potential enabled Serena to be a natural leader among her team by always attempting to keep "moving it forward" (Sawyer, 2007, p. 53). Her motto was to "just make sure you

pick the right [teammates] by paying attention to what they do" (Focus group interview, March 31, 2012). Seeking others who shared her perspective, dedication, and possessed beneficial skills and talents, Serena noted that, "if you communicate right and the other person communicates right, then the job will be done" (Focus group interview, March 31, 2012).

"Oh, I got this." Inspired to liken the CSTEM Creative Writing Challenge to the lessons of her engineering teacher, Serena drew practical connections from her recent experiences to her aspirations for the future. When given the opportunity to reflect upon these recent experiences, Serena proclaimed that, "it shows me how creative and responsible I can be" (Focus group interview, March 31, 2012).

Seeing challenges and new obstacles as opportunity for growth and improvement showcases Serena's personal awareness and ability to build her knowledge and potential.

> "If I keep learning how to build things and think about things then I will be so good at engineering in my future. Now when I see a challenge I'll think, "oh, I got this" because I've learned how to figure things out and make it happen to get the job done" (Focus group interview, March 31, 2012).

The Relationship between Process and Product

The culmination of the findings rests with the rubric assessments from the Judges' view of the product and the researcher's view of the process upon the completion of the CSTEM Creative Writing Challenge. The volunteer judges spent all morning combing through the final products, which included pop-up books and videos. Though the challenge originally had 11 teams enrolled, *Team 2* and *Team 3* did not turn in products;

therefore, those two teams did not compete. Of the remaining nine teams, three of them (*Team 4, Team 5,* and, *Team 6*) did not turn in a video to accompany their pop-up book.

Judges' rubric scores of the product. As explained in the methodology chapter, the Judges' assessment of the final *product* utilized an analytic 15-item rubric with a total of 45 possible points, which was designed by the CSTEM curriculum development team (Appendix B). As indicated in the results from the judges' scores (Table 10), *Team 7* won first place by a definitive margin of nine points. *Team 11* won second place by a fraction of a point; however, there was a decisive difference in scores between the third place team, *Team 8,* and the fourth place team, *Team 4*. Interestingly, the winning team scored twice as many points as the last place team.

Table 10

Rankings Based on Judges' Scores for Product

Rank	Team	Average of Judges' Score for Product
1st	Team 7	42
2nd	Team 11	33
3rd	Team 8	32.6667
4th	Team 4	26
5th	Team 10	25
6th	Team 9	24.6667
7th	Team 5	23.3333
8th	Team 6	22
9th	Team 1	21.6667

Researcher's rubric scores of the process. The researcher's assessment of the *process* utilized an analytic 15-item rubric with a total of 30 possible points (Appendix C). The rubric, designed by Heider (2006), contained a list of 15 attribute dimensions that were used to assess the reflective, ethnographic videos created by the students. The use of this assessment tool heavily relied upon the student-creators' ability to digitally capture and communicate the process in which their teams engaged in. In looking at the researcher's scores, the ranks are significantly different from the Judges' scores for the final product (Table 11). Of significant importance is the fact that the team that ranked in first place for product, *Team 7*, ranked in fourth place for process. Additionally, the team that ranked in last place for product, *Team 1*, ranked in second place for process. Note that there was a three-way-tie for last place according to the researcher's scores for process because there were three teams that did not turn in a reflective video as per the competition criteria.

Table 11

Rankings Based on Researcher's Scores for Process

Rank	Team	Researcher's Score for Process
1st	Team 11	38
2nd	Team 1	37
3rd	Team 8	29
4th	Team 7	26
5th	Team 10	26
6th	Team 9	22
7th	Team 4	0
8th	Team 5	0
9th	Team 6	0

Wilcoxon signed-rank test results. The Wilcoxon Signed-Rank Test was the statistical measure used because the two rubrics were providing rankings from the same set of participant teams. As stated in chapter 3, this inferential statistical method uses nonparametric techniques to analyze small sample sizes by calculating the difference between two sets of ranked data (Frankel & Wallen, 2009). The ranks table (Table 12) provides a comparison of the judges' assessment of the product and the researcher's assessment of the process. The results indicate that six of the teams ranked higher based on their product score compared to their process score with a mean of 5.83. However, three teams ranked higher based on their process score compared to their product score with a mean of 3.33.

Table 12

Wilcoxon Signed-Rank Test Examining Process and Product

Ranked Data for Comparison

Team	Judges' Score for Product *(Rank)*	Researcher's Score for Process *(Rank)*
1	21.6667 *(9th)*	37 *(2nd)*
4	26 *(4th)*	0 *(7th)*
5	23.3333 *(7th)*	0 *(8th)*
6	22 *(8th)*	0 *(9th)*
7	42 *(1st)*	26 *(4th)*
8	32.6667 *(3rd)*	29 *(3rd)*
9	24.6667 *(6th)*	22 *(6th)*
10	25 *(5th)*	26 *(5th)*
11	33 *(2nd)*	38 *(1st)*

Wilcoxon Signed-Rank Test Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Product	9	27.8148	6.74971	21.67	42.00
Process	9	19.7778	15.69058	.00	38.00

Ranks

		N	Mean Rank	Sum of Ranks
Process - Product	Negative Ranks	6[a]	5.83	35.00
	Positive Ranks	3[b]	3.33	10.00
	Ties	0[c]		
	Total	9		

a. Process < Product
b. Process > Product
c. Process = Product

The Wilcoxon test was conducted to evaluate whether there was a relationship between each team's process and product. The results (Table 13) indicate a statistically

significant difference between process and product, $z = -1.481$, $p < .14$. These results indicate that there is not a positive correlation between the process and product.

Table 13

Wilcoxon Signed-Rank Test Statistics

Test Statistics[b]

	Process - Product
Z	-1.481[a]
Asymp. Sig. (2-tailed)	.139

a. Based on positive ranks.
b. Wilcoxon Signed Ranks Test

This chapter presented the findings in relation to themes that unfolded across the data sources in order to provide answers to the two research questions. By identifying shared traits of the teams' collaborative design processes and exploring the relationship between process and product, these findings indicate that this project-based learning experience allowed students to become self-aware of their ability to make meaningful connections that span multiple literacies, develop an altruistic outlook on the environment through empathy towards their local community, and cultivate a series of life lessons in character which will benefit them in their future endeavors. Statistical investigation showed that ratings of the pop-up book product did not parallel ratings of the process, as revealed by interactive videos.

Chapter V

Discussion

The results from this study did not uncover a correlation between the process and product; however, the identification of shared traits amongst the team processes and the self-reported development of multiple literacies, altruism, and life lessons point to a need to discuss the cognitive and psychosocial benefits of this collaborative design experience. This chapter will build upon the results by providing a discussion of the true relationship between process and product and how PK-12 education can honor that relationship by achieving a balance between creativity and rigor through the use of student-created reflective video as a performance-based assessment in project-based learning.

The True Relationship between Process and Product in PK-12

The team competition aspect of the *CSTEM Creative Writing Challenge* allowed these students to face real world trials of engaging creativity and collaboration. Though the heart of the study was to identify ways in which these diverse teams engaged in collaborative design, the importance of their personal growth from the experience itself begs to be a centerpiece of the discussion. To articulate a proper discussion of the significance derived from this study the researcher will rely on a quote from the previous literature, "the means to the end can be as meaningful as the end product itself" (Hernandez, et al., 2010, p. 5). Though there may not have been a direct correlation between the two in the case of these findings, perhaps the means to the end (the process, including creativity and collaboration) can be even more meaningful than the end product (the pop-up book) because the students in this challenge expressed an enlightenment of a multitude of real-life skills and new knowledge. This is in line with Sonnenwald (1996)

who demonstrated that experiential learning takes place throughout the design process as it enables the learner to develop new artifacts, experiences, and knowledge.

Cognitive benefits in collaborative design experiences. The findings indicated that the teams who participated in this study shared three methods of process, which included researching and brainstorming, decision-making and collaboration, and critical-thinking and problem-solving. It is important to note again that these methods are recognized as valuable 21st century skills by a variety of national education organizations (i.e. ISTE, NAEA, NCTE, P21). Regardless if the team came in first place or not, each team discussed the iterative nature of the design process and how they overcame problems in order to complete the product. For some students, they reported benefitting from the collaborative opportunity to try something they had never tried before while others reported benefitting from learning to be resourceful, which are both key to innovation.

Due to the nature of the actual creative writing challenge, multiple literacies were authentically woven into the experience. Students contended with the words of verbal literacy, images of visual literacies, and interactions of scientific environmental literacy to create a peer level creative non-fiction pop-up book. Through hands-on exploration that began with inquiry then culminated with the final production of the creative product, students noted how they were able to make connections between concepts, subjects, and modes of representation. This ability to be critical of experiences is what Greene (1995) referred to as "sense-making" in which individuals are aware of what is around them through multiple lenses and are capable of interpretations that produce meaning. To be able to "see beyond what the imaginer has called normal" allows for new perspectives.

This is important because "imagination is the one [cognitive ability] that permits us to give credence to alternative realities. It allows us to break with the taken for granted, to set aside the familiar distinctions and definitions" (p. 3).

Psychosocial benefits in collaborative design experiences. Having opportunity for sense-making, or, constructively looking closer at and reflecting upon experiences, students in contexts such as these collaborative design experience are able to more deeply seek meaning in their world. Much like Bruner (1974) and Gardner (1990), Greene (1995) noted that humans are intrinsically curious beings who crave creative and meaningful expressions throughout their daily lives. As opposed to the monotony that the test-driven society has enforced upon children by seeing the world as a series of "small" quantifiable patterns, Greene suggested a "big" world where particularistic details and narratives are enlarged to explore and enrich our understanding of experiential learning.

In the context of exploring one's own community, this experience allowed students to develop empathy which was expressed through a variety of altruistic statements. Through research and inquiry, students created peer level creative non-fiction books to inform their school community and even extended that with a desire to inform and teach the community at large how they could come together and reverse the damage that the dead zone had caused in their area.

This altruistic inquiry naturally extended into life lessons, which included collaboration, communication, creativity, and work ethic. These themes were repeated throughout the data from each team as they expressed the importance of a strong work ethic, intrinsic motivation, effective communication, how to deal with diversity, and ultimately how to learn from every experience in order to enhance one's future.

The Balance between the Flexibility of Creativity and the Rigor of Measureable Criteria

The researcher now comes full circle, back to the fact that creativity and collaboration are process-based skills that need to be developed in PK-12 education. Though they are each components of national standards in every content area, the reality is that education often places more emphasis on the measureable criteria of the final product rather than the flexible creativity of the process used to create the product. Case in point, the CSTEM Creative Writing Challenge awarded first place to the team that scored the highest on the product quality rating rubric, not the team that communicated learning the most valuable life lessons, nor the team that expressed an unselfish awareness of the environment and how they could do their part to make their local community better. That said, the winning team (Team 7) did indeed produce the best pop-up book and did in fact produce a high quality video with a clever portrayal of a student playing the role of teacher who imparted scientific environmental wisdom upon her students. At first glance, this video appeared to be more polished because it had a scripted performance that demonstrated the finished pop-up book product, complete with all of the "bells and whistles" of video production which included music, titles, and credits. Though *Team 7*'s video was indeed entertaining and creative, in comparison with some of the other videos it did not provide as much insight into the overall design process that the team engaged in or the team culture.

Student-created reflective videos in PK-12 project-based learning. What began as a simple means to encourage the development of student-generated data turned into the significant centerpiece of the results. Student-created reflective videos are a

practical way to allow students the flexibility of creativity to make a personally meaningful media production which has the capacity to not only allow for reflection but also allow for the communication of rigorous measureable criteria within a project-based learning experience. Given the ubiquitous nature of video production tools (camera phones, handheld video cameras, free video editing software, and the ability to freely upload the finished video to the Internet), this performance-based assessment is a practical balance of creativity and rigor. This type of creation allows the student to be the ethnographer of their own learning experience while they inquire into both their learning process and how the creation of their artifact meets the goals and objectives of the PBL. After all, in the PK-12 context educators should place emphasis on the process because students need these types of experiences in order to develop and practice viable real world skills to become better prepared for life (Goldman, 2004, 2007; Kearney & Schuck, 2005).

Research on digital video as a reflective tool for pre-service teachers is available; however, there is little research available on the value of PK-12 student-created video for their own learning. Schwartz and Hartman (2007) framed this type of performance-based assessment for pre-service teachers as a type of performance-based assessment around four common learning outcomes, 1) engaging, 2) saying, 3) seeing and, 4) doing (p. 337). Their model also aligns learning targets, assessments, and genres to provide a holistic view of the value of a reflective video experience. This approach could provide a foundation to explore ways in which PK-12 educators could use student-created reflective videos to assess both the process and the product in PBL.

This study utilized two rubrics, one in which the judges assessed the final product (including the pop-up book and reflective video) and the other in which the researcher assessed the process. Upon reflecting on aforementioned literature and the findings that resulted from these two assessment tools, the researcher proposes a rubric that simultaneously assesses process and product in similar PK-12 project-based learning experiences that involve collaborative design. Using Schwartz and Hartman's (2007) four common learning outcomes to frame a synthesis of Heider's (2006) ethnographic attributes with the current product quality criteria components, the following rubric will serve as a starting point for future exploration (Table 14).

Seeing as *Team 7*'s video was so entertaining and creative, the first learning outcome of the rubric addresses the power of engaging the audience with a pleasing technical structure, including the multimodal literacy of basic technical competence and the appropriateness of sound, visuals, and communication. After all, video, like writing, should be clear, organized, and add meaning to the communication. The second learning outcome addresses the importance of what is actually communicated through topics of discussion within the reflective video, including contextualization of the problem, related concepts, acknowledgement of the design process, the relationship to the final product, and reflection of the future impact of this experience and/or product. This component allows students to authentically consider what they have learned and the implications of their PBL experience, as seen in *Team 11*'s video. The third learning outcome addresses what the students see through their ethnographic inquiry about "whole people," "whole acts," and "whole places" to develop a sense of the cultural experience during the PBL. *Team 8*'s video provided an ethnographic window into their collaborative design process

through a series of snapshots as well as allowed the viewer to develop an emotional connection to the students who passionately discussed a need for humans to consider the harm they cause for other living things on the planet. The fourth and final learning outcome addresses what the students are doing as seen through their documented behavior in the video, including explanation and evaluation of various distortions, time distortion, continuity distortion, inadvertent distortion of behavior, and intentional distortion of behavior. *Team 1*'s video demonstrated the power of showing real time sequences free of distortion in which individuals and groups discussed the task that they were working on at that moment.

Table 14

A Proposed Rubric for Evaluating Student-created Reflective Videos in PK-12 PBL

Learning Outcome	Criteria	Unacceptable (0)	Acceptable (1)	Exemplary (2)
ENGAGING: Technical Structure	**Basic Technical Competence**	distracting incompetency	reasonable competency	exceptional competence
	Appropriateness of Sound	distracting sound	reasonable narration	natural synchronous sound
	Appropriateness of Visuals	distracting visuals	reasonable visuals	natural synchronous visuals
	Appropriateness of Communication	distracting, redundant, and/or unrelated	narration relates reasonably well	enriches meaning with exceptional relevance to visuals
SAYING: Topics of Discussion	**Contextualization**	no acknowledgement of the context of the problem or task	attempts toward contextualization	exceptional contextualization
	Related Concepts	no acknowledgement of related concepts	some acknowledgement of related concepts	exceptional acknowledgement of related concepts
	Design Process	no acknowledgement of design process	some acknowledgement of design process	exceptional acknowledgement of design process
	Relation to Final Product	no relation to final product	reasonable integration with final product	exceptional integration with final product
	Future Impact	no acknowledgement of future impact	some acknowledgement of future impact	exceptional acknowledgement of future impact
SEEING: Ethnographic Perspective	**Student as Inquirer**	student's presence ignored by video	student's presence mentioned	student shown interacting and gathering data
	Whole People	faceless masses	some attempt to represent the people	develops feeling for an individual
	Whole Acts	fragmentary bits of acts	some whole acts	beginning, peaks, and ends of acts
	Whole Places	generic places and scenes	some whole places	develops a complete sense of the place where events took place
DOING: Behavior	**Explanation and Evaluation of Various Distortions**	no acknowledgement in video	some attempt	fully acknowledged
	Time Distortion	temporal sequences rearranged	condensed time	real time
	Continuity Distortion	single sequences constructed out of shots from many actual events	some attempt to show actual sequences	actual sequences preserved
	Inadvertent Distortion of Behavior	extreme	moderate	minimal
	Intentional Distortion of Behavior	extreme	moderate	minimal

Note. Inspired by Heider's (2006) *Attribute Dimensions of Ethnographic Video* and Schwartz and Hartman's (2007) *A Space of Learning for the use of Designed Video*.

Recommendations

The presentation of this study provided multiple views of one collaborative design experience, including a multifaceted student view which showed their process as well as their self-reported benefits, the Judges' view of the effectiveness of the product, and the researcher's view of the design process. In doing so, this study contributed to the understanding of collaborative design in the context of PK-12 education by identifying similar process methods between a variety of teams from various U.S. regions. The researcher's primary goal of this study was to use ethnographic methods to express the reality of the collaborative design experience by weaving direct narratives from actual participants. Through this, the researcher strove for "a credible account of a cultural, social, individual, and communal sense of the 'real'" (Richardson, 2000, p. 254). Of note, the presentation of this study was written in a manner which honestly positioned the researcher's role and perspective, while also providing adequate room for the reader to interpret and think reflexively about the concepts contained within the presentation.

The cognitive benefits, psychosocial benefits, and life lessons that these students voiced throughout their reflection provided a testament to constructivism and experiential learning. This study maintained that presenting students with the opportunity to engage in inquiry-based video making of the process that they went through during PBL activities allowed them to authentically and formally address the life lessons that they developed. As indicated previously, there is little research on PK-12 student-created reflective videos and their value for addressing cognitive and psychosocial benefits. Future research might formally address the manner in which students create such videos and/or refine an assessment tool that PK-12 educators could practically use in their classrooms.

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Appendix A

2012 CSTEM Creative Writing Challenge Description

~2012 CSTEM Creative Writing Challenge Description~

For the CSTEM Creative Writing Challenge students will use digital fabrication to develop **one pop-up book** (a peer-level, illustrated, informational guide that discusses the Dead Zone specific to their region) and create **one reflective video** to serve as a virtual interview.

Collaborative Pop-up Book Criteria
Students will collaboratively create one pop-up book that contains three informational chapters (one chapter for each school level) that will consist of a total of 9 page spreads (which is the equivalent of 18 pages) and a bound cover. Each chapter will consist of 3 page spreads (the equivalent of 6 pages). The students will use digital fabrication and handcrafted techniques to make pop-up and movable mechanisms that illustrate their writing. The pop-up book will consist of five characters, three of which are provided: Slippery, Squirt, and Sprout. The two additional characters must be the sea turtle specific to your region and a robot. These characters must be consistent throughout the collaborative pop-up book.

Chapter Requirements:

1. Elementary school group will create a chapter that tells the story of the sea turtle journey around the Dead Zone.
2. Middle school group will create a chapter that tells the story of the Dead Zone.
3. High school group will create a chapter that explains how “bio-fuels”, created from algae produced in the Dead Zone, can improve the quality of life in their community.

Topics to Consider within the Chapters:
a) discuss causes of the growing size of the Dead Zone specific to your region
b) prevention methods and student generated strategy specific to your region
c) effects the Dead Zone has on sea turtles specific to your region
d) contributing factors the Dead Zone has on water pollution specific to your region

Collaborative Reflective Video Criteria
Students will collaboratively create one reflective video for the entire feeder pattern team that showcases the creation of their pop-up book. The feeder pattern team must work collaboratively to construct a video that documents the work process of the project, demonstrates how to read and interact with their completed pop-up book, and addresses the impact their pop-up book will have on the school community and the community at large. The video should be formatted as student interviews explaining methods and processes used in the creation of their pop-up book, include examples from the process (photographs or video sequences), and reflect upon the collaborative experience. The video should not exceed 4 minutes and should be embedded on the feeder pattern team Prezi.

NOTE: Presentation must be submitted at time of registration March 29, 2012 or March 30, 2012. Late
submissions will not be judged. Student informational guide pop-up book must be submitted at the time of registration and will be returned to exhibit booth at the time of judging.

Appendix B

2012 Rubric for CSTEM Creative Writing Challenge

Criteria	Unacceptable (0)	Acceptable (1)	Recognized (2)	Exemplary (3)
Pop-up Book Design - Overall Appearance (The pop-up book should be well made.)	Book has an unprofessional appearance with less than 18 completed pages, insecure binding, and lacks a cover with identifying information. Page design is confusing with an inconsistent style, layout, and is lacking neatness.	Book has a decent appearance with less than 18 completed pages, acceptable binding, front and back cover with title and school name. Page design is acceptable with a somewhat consistent style, layout, and neatness.	Book has a somewhat professional appearance with 18 completed pages, secure binding, front and back cover with title and school name. Page design is attractive with a consistent style, layout, and neatness.	Book has a very professional appearance with 18 completed pages, secure binding, front and back cover with title and school name. Page design is exemplary with a very consistent style, layout, and neatness.
Pop-up Book Design - Illustrations (Illustrations should have purpose.)	Illustrations do not relate to the text. Fewer than 3 of the 5 required CSTEM characters were used.	Most of the Illustrations are related to the text but do not make it easier to understand. 3 of the 5 required CSTEM characters were used.	All Illustrations are related to the text and most make it easier to understand. 4 of the 5 required CSTEM characters were used.	All Illustrations are related to the text and all make it easier to understand. All of the 5 required CSTEM characters were used.
Pop-up Book Design – Chapters & Content (Book should have three, clearly defined chapters that discusses a region specific Dead Zone.)	Book does not have chapters and does not address the specific information from the challenge description.	Book has two of the three chapters, but it is difficult to understand how the chapters relate to the Dead Zone.	Book has three chapters that address the Dead Zone, but it is difficult to distinguish between the chapters.	Book has three, clearly defined chapters, which flow together to create a very clear understanding of the Dead Zone.
Pop-up Book Design - Pop-ups & Movable Elements (Illustrations should pop-up or be movable & interactive.)	The book has 3 or fewer movable elements.	The book has 4 movable elements. Most of the elements are similar in design.	The book has 5 movable elements. The elements vary a little bit.	The book has more than 5 movable elements. Each of the movable elements varies from one another and adds interest to the writing.
Writing – Ideas (Ideas should be creative and informative.)	Writing is not creative or original. Topic and focus are confusing. Facts are not accurate or relevant to content. Author assumes the reader has a large amount of prior knowledge or understanding of the topic.	An attempt was made to be creative and original. Topic and focus are attempted. Some facts are accurate and relevant to content. Author assumes the reader has a large amount of prior knowledge or understanding of the topic.	Writing is creative and original. Topic is stated and maintained. Most facts are accurate and relevant to content. Author assumes the reader has some prior knowledge or understanding of the topic.	Writing is extremely creative and original. Topic, including focus or controlling idea, is skillfully stated and maintained. All facts are accurate and relevant to content. Author assumes the reader has no prior knowledge or understanding of the topic.
Writing – Organization (Organization should help the reader understand the information.)	Organization is unclear. Conclusion is not attempted. Sources are not listed.	Organization is somewhat clear. Conclusion is attempted but does not provide closure. Sources are listed but are not formatted.	Organization is clear. Conclusion provides somewhat clear and provides closure. Sources are listed and some use proper APA formatting.	Organization is very clear. Conclusion provides clear and precise closure. Sources are listed using proper APA formatting.
Writing – Voice (Student voice should be apparent throughout the writing.)	Student voice is not present. Enthusiasm for topic is not present.	Student voice is not consistent throughout. Enthusiasm for topic is lacking.	Student voice is consistent throughout. Enthusiasm for topic is sufficient.	Student voice is very consistent throughout. Enthusiasm for topic is strong.
Writing – Fluency (Fluency should create flow and connect ideas.)	Transitional words or phrases are not used.	Transitional words or phrases are attempted to maintain flow and rhythm.	Transitional words or phrases are used to maintain flow and rhythm.	Transitional words or phrases are skillfully used to maintain flow and rhythm.

Writing – Word Choice (Word Choice should be appropriate for the reader.)	Reader-level appropriate word choices are not used, and the words do not make sense.	Reader-level appropriate word choices are not used, but the words make sense.	Reader-level appropriate word choices are attempted.	Reader-level appropriate word choices are used.
Writing – Conventions (Proper conventions should be used to show a professional effort.)	Control of grammar, capitalization, punctuation and spelling is not evident.	Control of grammar, capitalization, punctuation and spelling is attempted.	Control of grammar, capitalization, punctuation and spelling is somewhat consistent.	Control of grammar, capitalization, punctuation and spelling is very consistent.
Reflective Video: Technical Structure of Video (4 minute time limit and embedded within feeder pattern team Prezi.)	Video is not embedded within the team Prezi and exceeds 4 minutes.	Video is embedded within the team Prezi but exceeds 6 minutes.	Video is embedded within the team Prezi but exceeds 5 minutes.	Video is embedded within the team Prezi and does not exceed 4 minutes.
Reflective Video: Depth of Student Reflection on Concepts and Design Process (Student reflection should discuss the overall experience, including how the feeder pattern team collaborated and the sequence of activities the team went through to design and develop the pop-up book.)	Video demonstrates a lack of student reflection of the concepts and design process experienced in this challenge. Viewpoints and interpretations are missing, inappropriate, and/or unsupported. Examples of the concepts and design process, when applicable, are not provided.	Video demonstrates a minimal student reflection of the concepts and design process experienced in this challenge. Viewpoints and interpretations are unsupported or supported with flawed statements. Examples of the concepts and design process, when applicable, are not provided or are irrelevant.	Video demonstrates a general student reflection of the concepts and design process experienced in this challenge. Viewpoints and interpretations are supported. Appropriate examples of the concepts and design process are provided, when applicable.	Video demonstrates an in-depth student reflection of the concepts and design process experienced in this challenge. Viewpoints and interpretations are insightful and well supported. Clear, detailed examples of the concepts and design process are provided, when applicable.
Reflective Video: Demonstration of Pop-up Book (Demonstration should show how to read through and interact with the book.)	Video does not demonstrate the pop-up book either neglecting the reading of and/or interacting with the pop-up/movable illustrations.	Video attempts to demonstrate the pop-up book, but the reading of and/or interacting with the pop-up/movable illustrations are confusing.	Video demonstrates the pop-up book and the reading of and/or interacting with the pop-up/movable illustrations is adequate.	Video demonstrates the pop-up book by reading and interacting with the pop-up/movable illustrations in a very engaging way.
Reflective Video: Community Impact (Video should address the impact the pop-up book will have on the school community and the community at large.)	Video does not address the impact the pop-up book will have on the community.	Video attempts to address the impact the pop-up book will have on either the school community or the community at large, but does not provide much detail.	Video addresses the impact the pop-up book will have on both the school community and the community at large, and provides some detail.	Video very clearly addresses the impact the pop-up book will have on both the school community and the community at large, and provides very clear details, such as examples and potential uses.
Reflective Video: Communication (Video, like writing, should be clear, organized, and add meaning to the communication.)	Communication of the video is unclear and disorganized. Thoughts ramble and make little sense. Audio and video components make it difficult to understand the overall communication of the video.	Communication of the video is unclear and/or difficult to hear. Thoughts are not expressed in a logical or organized manner. Audio or video components make it difficult to understand the overall communication of the video.	Communication of the video is mostly clear and easy to hear. Thoughts are expressed in a somewhat coherent, organized, and logical manner. Audio and video components do not make it difficult to understand the overall communication of the video.	Communication of the video is very clear, concise, and easy to hear. Thoughts are expressed in a very coherent, well organized, and logical manner. Audio and video components compliment and add to the overall communication of the video.

Appendix C

Heider's (2006) Attribute Dimensions of Ethnographic Video (p. 16)

Ethnographic Basis	uninformed by ethnography			deeply shaped by ethnographic understanding
Relation to Printed Materials	no printed materials	vaguely relevant printed materials	fairly well supported by printed materials	fully integrated with printed materials
Whole Acts	fragmentary bits of acts			beginning, peaks, and ends of acts
Whole Bodies	excessive fragmented close-ups			maximally necessary whole bodies
Explanation and Evaluation of Various Distortions	no acknowledgement in film or in print		some attempt	fully adequate
Basic Technical Competence	distracting incompetency		reasonable competency	exceptional quality
Appropriateness of Sound	inappropriate		moderate narration	natural synchronous sound
Narration Fit	redundant overly wordy, unrelated			originally demystifying and relevant to visuals
Ethnographic Presence	ethnographer's presence ignored by film		ethnographer's presence mentioned	ethnographer shown interacting and gathering data
Contextualization	isolated behavior shown out of context		gestures toward contextualization	well contextualized
Whole People	only faceless masses			develops feeling for an individual
Time Distortion	temporal sequences rearranged		condensed time	real time
Continuity Distortion	single sequences constructed out of shots from many actual events			actual sequences preserved
Inadvertent Distortion of Behavior	extreme		moderate	minimal
Intentional Distortion of Behavior	extreme		moderate	minimal