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Examining Bridges Between Informal and Formal Learning Environments: A Sequential Mixed Method Design

Dagen L. Valentine
University of Nebraska-Lincoln, dvalentine2@unl.edu

Examining Bridges Between Informal and Formal Learning Environments:

A Sequential Mixed Method Design

by

Dagen Lynn Valentine

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Examining Bridges Between Informal and Formal Learning Environments:

A Sequential Mixed Method Design

Dagen Valentine, M.A.S.

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Advisor: Bradley Barker

The purpose of this sequential mixed method study was to identify schools implementing a technology-based engineering design intervention in a way that connects or bridges formal learning environments of the school-day to informal learning environments such as afterschool programs. Further, this study investigated educators' decisions that enabled or facilitated bridging between formal and informal learning environments. This cooperation and/or linking between informal and formal learning time is bridging. Participants included public schools (n=16) in Eastern Nebraska that incorporated the Nebraska Wearables Technology (WearTec) program at their school, club or Out-of-School-Time program during the 2015-2016 school year. Three of the schools bridged formal and informal environments. For this study descriptive statistics were used to analyze the implementation of the WearTec curriculum and as a means to select schools which bridged the formal and informal learning environments. Interviews with *a priori* codes and thematic analysis were analyzed in a matching/exploratory case study of the schools that bridged formal and informal learning environments (n=3). Thematic and descriptive analysis of interviews suggests a pair of educators can create a bridge due to the WearTec curriculum, state standards, and interpersonal communication. Also, a single formal day teacher can create a bridge by creating informal learning opportunities in out-of-school time.

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Chapter 1: Introduction

"*. . . we need young people—a smart kid coming out of school—instead of wanting to be an investment banker, we need them to decide they want to be an engineer, they want to be a scientist, they want to be a doctor or teacher*."

President Barack Obama on *NBC's The Tonight Show*, March 19, 2009

The National Research Council (2010) in the report *Rising Above the Gathering Storm, Revisited* stated that only 4% of the American workforce is comprised of scientists and engineers, creating jobs for the other 96%. Jobs in the Science, Technology, Engineering, and Mathematics (STEM) fields are projected to grow by 29% from 2008 to 2018, while non-STEM jobs are expected to grow by merely 9.8% for the same time period (Langdon, McKittrick, Beede, Khan, & Doms, 2011). President Barack Obama encouraged youth to pursue careers as scientists and engineers to have a profound impact on the American economy and jobs. Unfortunately, many of today's youth are unprepared for STEM careers (National Science Foundation, 2014). For example, 75 percent of U.S. 8th graders were not proficient in mathematics in 2010 (NRC, 2015). Additionally, U.S. fourteen-year-olds rank 21st out of 30 in international science tests (NRC, 2010). These statistics reveal the urgency for quality programs that engage and inspire youth to enter STEM careers. One such result of this urgency is President Obama's Educate to Innovate initiative created in 2009 ("Educate to Innovate," n.d.). A key part of any child's success in the STEM fields is creating educational experiences that include project-based learning, hands-on activities and building a love of lifelong learning (PCAST, 2010).

1.1 Problem Statement

The problem of getting students interested in STEM fields in order to pursue STEM careers is a lack of exposure to learning experiences and engagement in STEM (Maltese, Melki, & Wiebke, 2014). For example, in the report *Engineering in K-12 education*, Katehi, Pearson, and Feder (2009) estimated only 10% of K-12 students have had instruction in engineering. While schools have traditionally been tasked with educating youth in STEM content, out-of-school time (OST) has been identified as an environment that can effectively promote learning of STEM concepts (Barker & Ansorge, 2007; Dabney et al., 2012; NRC, 2015). The NRC (2015) identifies one of the essential criteria for productive STEM out-of-school time programs is to connect STEM learning in formal and informal settings such as school, home, out-of-school-time, and other settings. Creating bridges between the formal and informal environments can connect the curricular worlds youth live in (Noam, Biancarosa, & Dechausay, 2003). Student involvement in OST programs is linked to greater engagement in learning including better school attendance and a greater sense of connection to the community (Miller, 2003). Students who do not find interest in STEM will not pursue STEM beyond the requirements of school (Lyon, Jafri, & St. Louis, 2012).

1.2 Audiences that will benefit

Researchers are not the only ones that will benefit from this study. Out-of-school programs will benefit from mixed methods study identifying characteristics of a bridging model. Also, out-of-school program developers will be able to identify possible areas of entry to formal school environments. Most importantly, youth enrolled in out-of-school programs will benefit from a concerted effort to improve exposure and interest to STEM content in the formal *and* informal learning environments. Organizations creating youth STEM activities will benefit from an exploration of an intentional curricular design that allows implementation during the formal school day and out-of-school environments.

1.3 Purpose

The purpose of this study was to learn more about the implementation of an intervention in formal and informal learning environments, as well as examine potential bridges of the two. Participants were certified teachers and out-of-school staff implementing the WearTec curriculum for 4^{th}-6^{th} grade students in Eastern Nebraska. An explanatory sequential mixed methods design was used to explain the quantitative results with in-depth qualitative data (Creswell & Plano Clark, 2011). In the first quantitative phase of the study, implementation log data from educators was recorded during implementation in addition to a post treatment survey to assess to what extent adherence, exposure, and setting of the curriculum were implemented as the curriculum developers intended. The second qualitative phase was conducted as a follow up to help explain the quantitative results. In this exploratory follow-up, the plan was to identify and explore the practical conditions that allowed, if any, for bridging of the formal and informal learning environments.

1.4 Research Questions

The central question guiding this study was: How are formal and informal bridges implemented?

1) To what extent does the use of the WearTec curriculum engage teachers and OST educators to utilize and integrate STEM into formal and informal environments?

2) Based on implementation, how do schools successfully bridge the formal school environment and informal environment?

3) In what way does a case study describing the bridging model help to explain the implementation of the WearTec curriculum?

Chapter 2: Literature Review

2.1 State of STEM Education

There are clear hurdles to getting youth into the science, technology, engineering and mathematics (STEM) career pipeline. The STEM pipeline is a metaphor for the educational journey students potentially take from youth to a career in a STEM field. In a STEM pipeline youth "develop an interest in STEM by middle school, choose particular courses in high school, and continue consistently and progressively with STEM study in college in order to end with a degree and career in STEM (Lyon et al., 2012, p. 48)." A study by Maltese & Tai (2010) corroborates developing interest in STEM before middle school by asking STEM graduate students and professionals when their interest in STEM began. To reiterate, developing an interest in STEM has a positive effect on STEM self-efficacy and career expectancy (Nugent et al., 2015). Participation in formal STEM curricula and other kinds of STEM education like OST clubs or programs can increase students' engagement and interest. (NRC, 2011).

However, interest alone does not sustain forward movement in the pipeline. Capacity building of the youth in order to assure they have the skills and knowledge needed to advance to more rigorous content in the sciences is essential (Jolly, 2004). Unfortunately, pervasive low scores in international standardized tests possibly illuminate an issue in STEM education. The United States ranked 25th in math and 21st in science (NRC, 2010). Little improvement on test scores in the US have been observed over the past 40 years (NRC, 2010). Not only do low grades impact the STEM pipeline, but a lack of policy and curricular choices by American educational institutions can have an effect on student participation in engineering. A report on Engineering in K-12 education, Katehi, Pearson, and Feder (2009) estimated only 10% of K-12 students have had instruction in engineering. In summary, youth interested in STEM need exposure to content, and that content should include rigor, and engagement.

Children learn through multiple, varied, independent, and inter-dependent experiences across time and settings, it is incumbent upon educational designers and leaders in both formal and informal learning environments to provide experiences that leverage prior and future programs, and help to build coherence and meaning, across settings, around critical ideas and understandings in science (Bevan et al., 2010, p 18).

In order to explore informal and formal bridging further we will need to separate them for moment and examine them in each in-turn. Additionally, I will describe the WearTec curriculum and discuss how WearTec is positioned to potentially serve as a tool in bridging informal and formal learning environments.

2.2 Learning Environments

Today's formal educational system is in the height of the standards-based reform (Barton, 2009). Within the standards-based paradigm, a particular way of thinking and doing emerges that affects how students are taught. Standards based reform gained traction with the 1983 National Commission on Education Excellence report, *A Nation at Risk*. Strong action, tying assessment to standards, was taken in 2001 with the No Child Left Behind (NCLB) Act (Barton, 2009). Although, The NCLB Act was replaced with Every Student Succeeds Act in December, 2015 standards are still emphasized. Standards set expectations for what students are required to learn. Although each state can create their own standards, academic content and achievement standards *must* be established (Every Student Succeeds Act, 2015). Academic content standards describe the knowledge, skills and other understandings that schools should teach; achievement standards define various levels of competence in the challenging subject matter set out in the content standards (Hamilton, Stecher, & Yuan, 2008). There is a particular structure, organization and method with the explicit goal of the learner to gain knowledge, skills, or competencies (Werquin, 2010). In addition to the requirement of schools to continue using or establishing content standards the NCLB Act also changed the amount of instructional time designated for subjects, including STEM.

> *In the 2006- 2007 school year, for example, elementary schools (on a nationally representative survey) reported spending an average of 178 minutes per week on science instruction, 323 minutes on mathematics, and 503 minutes on English language arts. A closer look at those data revealed that 28 percent of districts reported decreasing their instructional time in science in elementary schools, with an average decrease in those districts of 75 minutes per week. In contrast, 45 percent of districts reported increasing instructional time for mathematics in elementary schools, with an average increase of 89 minutes per week.*

(National Research Council, 2011)

As described, the formal environment is structured around time and standards, these structures in formal environments may be necessary for serious engagement in subject matter and science careers (Bevan et al., 2010). In contrast to formal environments, informal settings include low-stakes environments, group learning, and flexibility that allow learners to work at their own pace and develop their own interests (Bevan et al., 2010).

Informal education does not conform to a systematic view of education, but is characterized as learner-motivated, voluntary, and personal while generally furthering inquiry and enjoyment (NRC, 2009). Opportunities for learning science occur in everyday experiences; designed spaces such as museums, zoos; community based organizations; OST programs; and science media such as radio, television, and the internet (NRC, 2009). Informal learning environments, such as OST programs, are not subject to the same time and content standards as formal learning environments are. They are organized to allow flexible use of time and pace and are low-stakes in which student's work is not matched to a particular standardized measure. Youth OST programs "have been found to include physical and psychological safety; appropriate structure; supportive relationships; opportunities to belong; positive social norms; support for efficacy and mentoring; opportunities for skill building; and integration of family, school, and community efforts," (Bevan et al., 2010, p. 25). Within these informal interactions OST programs have been shown to contribute to youth's interest in and understanding of STEM (NRC, 2015). OST science programs position themselves as a delivery system for high quality informal science education with shared goals of authentic hands-on, learner-directed activities (Schwartz & Noam, 2007).

2.3 Bridging

The academic structure in which students experience STEM content during the formal day can be enhanced and expanded in informal settings such as OST. Furthermore, the exploration and construction of meaning from informal learning experiences can be given an academic context and potentially increased rigor within the formal day. A formal-informal collaboration can *bridge* these two seemingly dichotomous views for the benefit of the student.

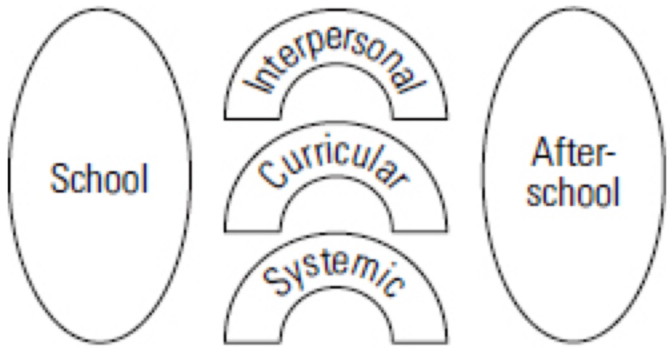


Figure 1. Noam et al. (2003) Bridging typology

There are three main forms that bridging can take: interpersonal, curricular, and systemic (Noam et al., 2003). Interpersonal bridging describes the interactions between school and OST staff. These interactions can be chance meetings to regular meetings. The second form of bridging, curricular, consists of the varying degrees in which the two environments attempt to align curriculum and standards. Thirdly, systemic bridging is made of formal collaborations and decision making between the school and OST program (Noam et al., 2003). Bridging can potentially increase interest and academic content knowledge in STEM leading to a higher probability of staying in the STEM pipeline. Bridging may not be a panacea for a potentially leaky STEM pipeline, but the practice of bridging can position programs to serve students' needs.

The following describes how the WearTec program fits into the goal of providing quality STEM education in both formal and informal learning environments. I also describe how WearTec could be implemented as a bridge.

2.4 WearTec

The Wearables Technology Project (WearTec) is grant funded though the National Science Foundation (NSF), Division of Research and Learning specifically funded through the Innovative Technology Experiences for Students and Teachers (ITEST) program (DRL

#1433822). WearTec is a collaboration between University of Nebraska-Lincoln, University of Nebraska at Omaha and Nebraska Department of Education. The WearTec model seeks to increase interest in and skills in STEM and STEM careers in the 4th -6th grade. WearTec also expects to be implemented in informal, formal, and bridged learning environments.

Fitness bands, smartwatches, Google Glass, wearable cardiac defibrillators, and LED costumes are only a few examples of wearable technology. Wearable technology relies on principles of computer programming, circuitry, engineering and fashion design. For example, Lumo makes a tiny (2in x 1in x 0.4in) wearable device with multiple sensors, including an inertia measurement unit (IMU); accelerometer, barometer, and other sensors. These sensors track a person's biomechanics while running. The data gathered with this device are shared wirelessly to a mobile device where analytics occur. In another example, Silvr Linings, in 2010, made solar charging clothing which allowed the wearer to garner the sun's energy. Solar panels and conductive circuitry were included in the textile that made up the vest or pants. These products illustrate only a small fraction of the potential of wearable technology.

The WearTec program contends that wearable technologies will provide an excellent platform for hands-on activities as wearables are both exciting and can be personally relevant to the project creators. The components, sensors, LED's motors, and switches are relatively inexpensive (Buechley, Peppler, Eisenberg, & Kafai, 2013) making them ideal for learning activities.

The learning goals for WearTec activities have students learn and apply skills in: 1) engineering design process, 2) circuitry, and 3) computer programing. Additionally, a goal of the WearTec program is to design and deliver a set of learning experiences compatible in both settings and delivered by teaching teams of formal and informal education. These goals guided curriculum development.

The formal school day has an emphasis on standards, entry into the formal day necessitates standard alignment. All activities in the WearTec curriculum were aligned with Nebraska State Standards for 4-6th grades and the Next Generation Science Standards. Instructionally, a gradual release model Marzano (2011) describes as the Enhanced Discovery Learning model, can connect elements of informal and formal learning environments. The enhanced discovery model includes elements 1) direct instruction, 2) guided tasks to assist students, 3) opportunities to freely explore, and 4) tasks requiring learners to explain their own ideas and ensuring that these ideas are accurate by providing just-in-time instruction (Alfieri, Brooks, Aldrich, & Tenenbaum, 2011).

For example, a lesson from the WearTec curriculum that is tied to 4th and 6th grade standards in electricity explains and explores switches and buttons. The lesson begins in the formal environment with a guided task to create a badge with a switch using copper-tape, an LED, and a card-stock template of a badge. Following this guided task, a short direct instruction and discussion is led by teachers to solidify understanding and expel misconceptions. Lastly, students begin exploring switches and buttons in the formal environment. Students continue the activity in an informal environment, possible in an OST program where they are given a time-constraint free opportunity to use the engineering design process to develop and prototype their own switches and buttons.

The curriculum is developed this way so that the direct and guided instruction and activities will meet the expectations of the formal environment, while opportunities to explore and develop student's understanding in an exploratory fashion are included in informal environments. These elements have the potential to position the WearTec curriculum to be a tool that can bridge formal and informal environments.

The curriculum content has 5 ‘projects’ consisting of a set of lessons as shown in Table 1. The engineering design process is used throughout the 5 projects. The WearTec program consisted of a 3-day professional development training.

Table 1

WearTec Curriculum Projects

Project #	Lesson Name
1	Circuitry & Sewing
2	Microcontrollers
3	Computer Programming
4	Quilt Block
5	Design Challenges

Chapter 3: Design and Methodology

3.1 Research Design

Mixed methods research is a methodology that meaningfully integrates both quantitative and qualitative approaches and the combination of the strengths of each to answer research questions. The glossary of Creswell and Plano Clark's (2011) handbook defines mixed methods as "the collection and analysis of both qualitative and quantitative data, mixing the two forms of data, giving priority to one or both, using procedures in a single study or multiple phases of a program of study, framing these procedures within a philosophical worldview or theoretical lenses, and combining procedures into specific research designs that direct the plan for conducting the study" (p. 410) This study employed a sequential explanatory mixed methods design. This explanatory design or qualitative follow-up approach (Morgan, 1998), begins by conducting a quantitative phase and follows up on specific results with a second, qualitative phase (see Appendix C) for the procedural diagram of the present study. The rationale for mixing both types of data is that neither qualitative nor quantitative methods sufficiently answer the research questions by themselves. When used in combination quantitative and qualitative methods complement each other and provide a more complete understanding of the research problem (Greene, Caracelli, & Graham, 1989). The quantitative data will provide a general picture of bridging among participating schools, and the qualitative phase will enhance those results by explaining more fully the implementation of the WearTec curriculum in schools that bridge.

This is a good choice when a researcher can return to participants in a second phase of data collection or when only one type of data can be collected and analyzed at a time (Creswell & Plano Clark, 2011).

For the first phase of this study a longitudinal survey design was used to collect data about a trend with the same population over a period of time (Creswell, 2015). The cohort study of the longitudinal survey design was used to identify the environment in which WearTec was taught, thus identifying the subpopulation that bridged the formal and informal learning environments. The second phase in this mixed method design, qualitative, used a case study design. The case study serves to develop an understanding of the activity and process(Creswell, 2015) of bridging. The two strands were analyzed independently. Finally, the “mixing” or point-of-interface occurs at interpretation (Creswell & Plano Clark, 2011) so that each of the strands is integrated.

3.2 Quantitative Strand

Participants for the first phase were elementary or middle schools in the eastern part of Nebraska (n=16) participating in the WearTec program. Schools self-selected into the WearTec program. A recruitment phase completed by WearTec staff included word-of-mouth and contact at professional conferences. Interested teachers were required to register and participate in a 3-day professional development workshop in the summer of 2015. Teachers and afterschool staff from 16 schools attended the workshops.

During the implementation of the WearTec curriculum teachers were required to complete implementation logs after each class, club or meeting of WearTec. Implementation logs were completed using a survey in Google Forms or completed paper and pencil and submitted at the completion of implementation. Implementation data gathered included date and duration of the WearTec meeting. Also, lesson information was gathered about each meeting. Finally, teachers were asked to include the environment: informal or formal; and facilitating teacher. The entire survey is found in appendix B.

3.3 Qualitative Strand

Three schools were selected for phase two (qualitative) based on the criteria that they a) implemented WT curriculum in formal and informal environments thus creating a bridge and b) completed implementation surveys in quantitative phase one. Although three schools were identified, two schools had the same teacher. Structured interviews were done with the teachers of these schools. A one-on-on interview was also done with the teacher who had two schools bridge. Following interviews, the audio recording was transcribed. I transcribed the interviews by hand using an online transcription application (otranscribe.com). The interview transcripts were uploaded without names to Coding Analysis ToolKit (cat.texifter.com). Descriptive coding was used for first cycle coding of the data. *A priori* codes were pre-determined based on Noam's typology (Noam et al., 2003) and Formal-Informal Collaborations (Bevan et al., 2010) in order to identify characteristics of the bridging case. The original codes were: 'interpersonal communication', 'curriculum/standards', 'systemic decisions', 'informal environment', and 'formal environment'. Other codes emerged from the data including: 'direct instruction', 'self-efficacy', 'hands-on', and 'problem solving.'

Second cycle coding involved revisiting the data to permit further exploration and identification of themes. The codes were combined with the original *a priori* codes, which became the major themes. For example, 'direct instruction' fit under 'formal environment' and 'hands-on' seemed to fit under 'informal environment.' I created a new theme, "self-efficacy' and included 'problem solving' with-in this code. Additionally, direct quotes from the participants that fit under the 6 themes were identified.

To increase validity of the qualitative strand the analysis and description was shared with interviewees for member checking. Member checking was used to validate the accuracy of the accounts (Creswell, 2013).

Chapter 4: Findings

4.1 Quantitative Strand: Data Analysis

Sixteen schools participated in WearTec for the 2015-2016 school year. One school did not return the implementation log thus data from 15 schools are represented. In this study the response rate was 94%. Four schools (31%) implemented WearTec exclusively during the formal school day. Six (46%) schools implemented WearTec exclusively in informal environments. Three schools (19%) implemented WearTec with a bridge. The three schools that bridged were Roosevelt, Taft, and Coolidge. The implementation of the WearTec curriculum in formal and informal environments is shown in Table 2.

Table 2

Implementation of WearTec curriculum in formal or informal environments

School Name[a]	% formal	% informal
Washington	100%	0%
Jefferson	100%	0%
Monroe	100%	0%
Jackson	100%	0%
Harrison	100%	0%
Polk	100%	0%
Taylor	0%	100%
Pierce	0%	100%
Lincoln	0%	100%
Grant	0%	100%
Garfield	0%	100%
Cleveland	0%	100%
Roosevelt	32%	68%
Taft	94%	6%
Coolidge	94%	6%

a. Participating schools were given pseudonyms

Of the 31.25 hours Roosevelt implemented the curriculum, 10 hours (32%) was spent in the formal classroom setting. The formal classroom setting was used to teach sewing skills. The other 21.25 hours were spent completing the WearTec curriculum in the informal setting of an OST program.

Taft spent 94% of the instructional time in the formal day and the remaining time in the informal environment. The informal environment was used for computer programming and completing self-selected projects in the WearTec curriculum.

Coolidge was engaged in WearTec curriculum for 18 hours. Like Taft, 94% of the time was spent on WearTec during the formal day while the 6% of time was spent in informal time similar to Taft.

The 12 schools which implemented WearTec lessons solely in one environment had an average lesson length during the formal setting of .85 hours while the average lesson for the informal time was 1.17 hours. Although it is interesting that the formal setting implemented each class for a short time, the sample size is too small n=12 to determine if this is statistically significant.

The data from the implementation log was also used to identify how long each activity or lesson took to implement in addition to identifying when the bridge took place as shown in Table 3. The formal environments completed more lessons. Each of the six schools implementing only in the school day completed 4 out of 5 of the lessons, while Jefferson only completed two. Only Pierce in the afterschool environment completed three or more concepts while the other five schools implemented only the circuitry and microcontroller & sewing lessons.

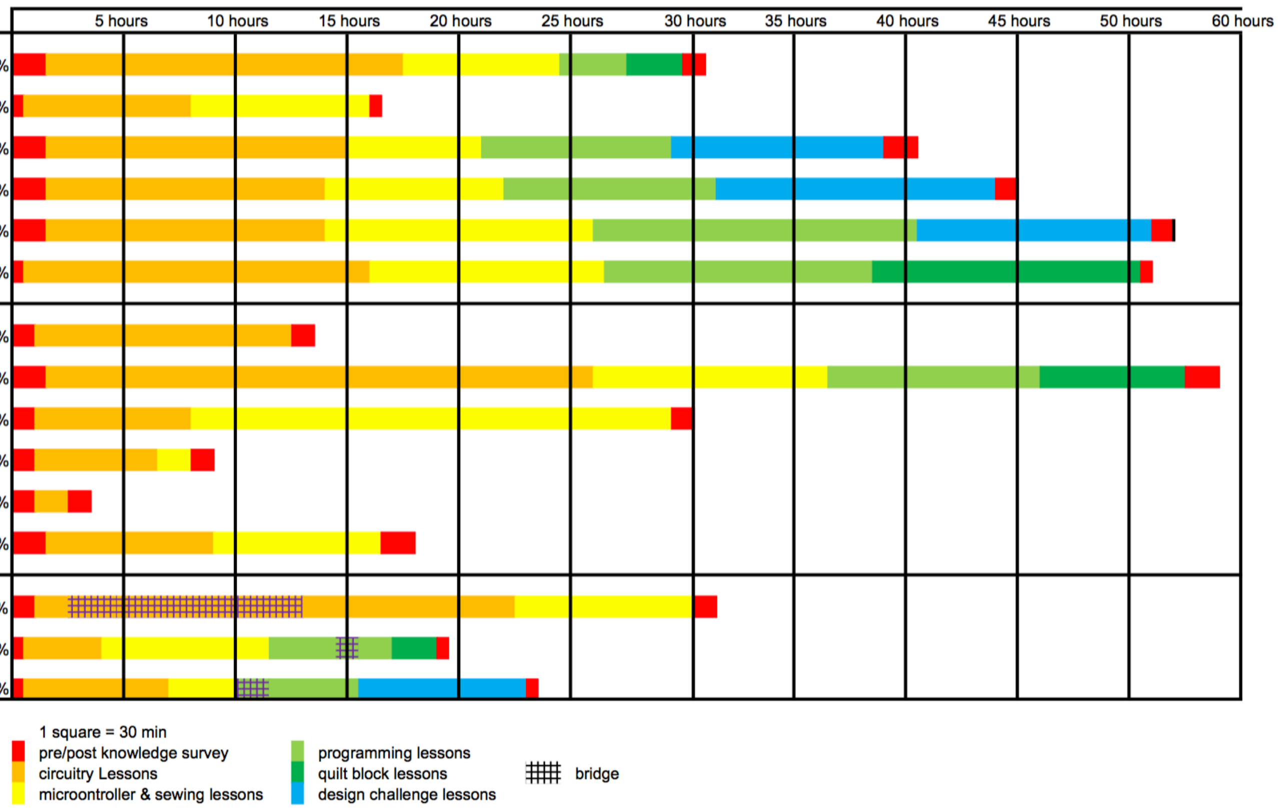
Research question 1: To what extent does the use of the WearTec curriculum engage teachers and OST educators to utilize and integrate STEM into formal and informal environments?

Three schools implemented the curriculum with a formal-informal bridge. The WearTec program was implemented in both formal and informal environments independently.

Table 3

Lesson Implementation of WearTec Curriculum

School	total time	% formal	% informal
Washington	30.50	100%	0%
Jefferson	16.50	100%	0%
Monroe	40.50	100%	0%
Jackson	45.00	100%	0%
Harrison	52.00	100%	0%
Polk	51.00	100%	0%
Taylor	13.50	0%	100%
Pierce	59.00	0%	100%
Lincoln	30.00	0%	100%
Grant	8.00	0%	100%
Garfield	3.50	0%	100%
Clevelent	18.00	0%	100%
Roosevelt	31.00	32%	68%
Taft	18.50	94%	6%
Coolidge	23.50	94%	6%



4.2 Qualitiative Strand: Data Analysis

The data collected in this study provided evidence of two of the three domains of bridging and systemic bridging evidence was not found as described by Noam (2003). Also, evidence of formal and informal environmental indicators were evident according to Bevan et al. (2010). The data from this phase of the study also revealed the importance teachers place on self-efficacy during implementation of WearTec. The themes of bridging are described in Table 4. The examples provided come from statements the students made during the interview portion of the study.

Table 4

Themes of Bridging

Themes of Bridging	Significant Statements from Participant Students
Interpersonal communication	"I asked if she would be interested…she agreed." "I feel like the people I work for and with their leadership style is from the superintendent as well, we all need to trust each other."
Curriculum/standards	"The lesson plans and the structure of the curriculum was really helpful to really know what I should be doing next." "If you can really sell them [the administrators] not sell them, but show them, where those connections are being made with the standards like you have, it's an integrative approach"
Systemic decision	NA
Informal environment	"For the informal time I just wanted to give an option for those kids to come after school and after school setting so they don't have to feel bound by that time and me not feel bound by that time." "It's just more relaxed."
Formal Environment	"There are time constraints during the school day." "Direct instruction, obviously, was when I was with them. and that took place and then the extension right 'before the next time I see you I would like you to look into this.'"
Self-efficacy	"I liked the student engagement." "…don't think that you have to know everything because really you want to build the kids up to be the problem solvers" "If they can do it once, then can do it twice"

Roosevelt Elementary is a K-6 school in a large urban district. The average attendance of the WearTec club was 15. The Roosevelt WearTec club was conducted by certified 5th grade teacher, Hanna, in the afterschool program while Olivia, the certified art teacher, conducted WearTec in the formal school day. Olivia taught the sewing skills in August and September according to the school and district art plan. Olivia started the sewing portion of the WearTec curriculum in October. An interview with Hanna was conducted after implementation of the WearTec club was complete. Hanna explained that teaching sewing skills in the school day was not part of the mandated state standards for art. However, Hanna clarified that the Fine Arts(FA) Standards allows the art teacher to use a medium of her choice when teaching some standards FA 5.2.1 states that, "Students will use the creative process to make works of art exploring subject themes with a variety of materials (Nebraska Department of Education, 2014 p1)." In order to create the bridge, Hanna approached Olivia to discuss the project and see if she was able to help with anything. They created a plan together: Olivia would make sure to teach the WearTec sewing skills during the school day to the 5th grade within the art standards. The described interaction between Olivia and Hanna was coded is an example of interpersonal communication and curricular bridging.

During the OST program in which Hanna conducted the WearTec club she appreciated the student engagement, problem solving skills, modeling, and "ah-ha" moments. She appreciated the building of self-efficacy: "If they can do it once, they can do it twice. If they can do it twice, they can do it three times. Then they start to challenge themselves."

Taft and Coolidge's WearTec curriculum was implemented by the same teacher, Sarah, a certified teacher in the district's Gifted and Learning program. Sarah teaches high ability learners in grades 4th – 8th. Sarah conducted both the formal and informal learning environments on her own for the WearTec curriculum. The majority of the time 94% was spent in the formal class, while the informal time was an informal environment in which students worked independently on their own projects.

The bridging that occurred at these two schools with this one teacher were structurally the same. An opportunity was provided for students to attend an open time to work on their projects with the support of Sarah. Sarah enjoyed the unstructured informal time, "…this [informal] was a little more laid-back. I would say there is significantly more amount of preparation for the formal because you have to make sure you know what you're doing so that way you can use the time wisely to prepare for those sessions."

Research question 2: Based on implementation, how did a school successfully bridge the formal school environment and informal environment?

In the case of Roosevelt, the bridge was created through two main factors: the interpersonal communication of the informal and formal environment teachers; and the connection to standards and curriculum. For Taft and Coolidge, the teacher placed importance on informal time and the unstructured, discovery learning that could take place.

4.3 Mixed Method Strand

Research question 3: In what way does the case study describing the bridging model help to explain the implementation of the WearTec curriculum?

By integrating the two sets of data an explanation of the circumstances of the bridging domains were found. In one case the implementation log indicated an informal OST program spent 32% of its time in a formal setting and the other 68% in an informal setting. Through interviews it was discovered that interpersonal communication between educators facilitated a curricular bridge with WearTec and art curricula. In the other case, interviews uncovered that a single teacher provided her students an opportunity to explore and discover in an open and informal environment for 6% of WearTec implementation.

Chapter 5: Discussion

The leading question of this study was to identify how formal and informal bridges were created and implemented. In order to answer this question a mixed method design was used to mix quantitative and qualitative strands. The summary of the findings looks at each research question in turn.

5.1 Summary of Findings

In what way was the WearTec curriculum implemented into formal and informal learning environments? Through quantitative analysis three schools (19%) were identified to have created a bridge by implemented the curriculum in both learning environments. One of these bridging schools predominantly provided instruction in the informal environment while the other had much less time in the informal environment, spending most of the implementation in the formal school day. Although these cases differ in bridging implementation, bridges may vary in intensity (Noam et al., 2003). Even with the varying intensities of the bridges, an alignment between school and afterschool curricula was established, representing a curricular bridge (Noam et al., 2003). In addition to the above bridging cases, the WearTec curriculum was used without bridging in informal of formal settings independently in 81% (n=13) of cases during the year. This demonstrates the capacity of the WearTec curriculum to be used in formal and informal learning environments. The potential of the WearTec curriculum to bridge is high and formal-informal collaborations can create more varied experiences and access to youth and teachers in science education (Bevan et al., 2010).

How did schools successfully bridge the formal school environment and informal environment? The qualitative findings suggest bridging the two learning environments was associated with a curricular bridge. Through interviews it was found that bridging was able to be utilized in the formal setting due to state standard alignment and inclusion of direct instruction. Evidence of intrapersonal bridging was also identified, however, systemic bridging was not. The choice to bridge the WearTec curriculum was meant to supplement a portion of the curriculum, not a 50/50 split between the two environments. The teachers involved in the bridging made specific environmental choices keeping the curriculum as the common thread between the two environments. The bridge relied on both the informal and formal environments to support children academically centered on content and standards (Noam et al., 2003).

In what way does a case study describing the bridging model help to explain the implementation of the WearTec curriculum? The bridging cases in this study showed a desire to supplement a portion of the curriculum with a bridge into either the formal or informal learning environments. The quantitative data showed a majority of time spent implementing the curriculum, not a 50/50 split, between the two environments. The quantitative data showed that three schools used a bridge to implement the curriculum. Through interviews and analysis, it was in fact the curriculum, through the use of state standards, that allowed WearTec to be implemented in both environments.

Bridging has the power to bring the informal and formal learning environments together to serve students' interest and skill development (Bevan et al., 2010). The WearTec curriculum was written with that intention. This current study reveals findings about the implementation of WearTec in formal and informal learning environments, each independently however. WearTec meets the needs of each of those environments with aligned state standards and direct instruction for the formal environment and engaging, hands-on instruction and activities for the informal environment. Additionally, the bridges that were identified were opposite of each other in time spent in each environment, with one teacher using the majority of time in OST and supplementing with formal day instruction and the other teacher doing the opposite. This finding is particularly relevant to OST staff and certified teachers informing them of the flexibility of the implementation environment while keeping fidelity to the curriculum.

5.2 Implications

This study identified that a curriculum can be written for formal and informal environments using STEM concepts. Formal and informal collaboration can lead to content rich and engaging science programs (Bevan et al., 2010). The implication brought forth that a curriculum can be designed for two learning environments leads to a potential for other content areas, such as language arts curriculum, be bridged by schools and OST time. Academic standards serve as an entry point into formal learning environments.

A second implication of this research is the potential to raise STEM literacy. WearTec provides opportunity and access to STEM content in the formal and informal environments. Engaging students in both rich pedagogically contrasting environments. Access to STEM literacy can be predictors of economic success and potential sorter for economic opportunities (NRC, 2011). In addition to economic opportunities for some, those who do not pursue STEM careers will be better prepared to adapt to changes in the science and technology driven society (NRC, 2011).

5.3 Limitations

This study was based strongly on a typology of Noam's informal and formal bridges. The study design, methodology, and analysis were selected in order to contribute to the understand bridging with the WearTec curriculum. The present study had several limitations that are worth mentioning.

The population selected for interviews to explain the bridging models did not have certified *and* non-certified teacher cooperation as intended in the WearTec grant. The original research study was intended to explore how two teachers, a certified and non-certified teacher collaborated in formal and informal environments to implement the curriculum. Also the population of bridging lead-teachers was two. Each created a bridge of a different type. Triangulation and other validity measures could have been used with more data sets from each type of bridging.

Limitations due to time constraints deserve to be mentioned. I was not able to do an in-depth interview for this study with one of the teachers due to district permissions and their own review board process. An initial request was denied. For her interview data, the exit interview was used. Without a personal interview I was unable to explore deeper the decisions and choices the teacher used to bridge.

5.4 Recommendations for Future Research

There is need for more research about what state, district and school decisions contribute to OST and school bridging. Future studies should include interviews with school and district leadership, because they may be able to provide more global information about systemic decision that may contribute or hinder the creation of an informal-formal bridge. Additionally, schools or OST programs that implement the WearTec curriculum without bridging may be examined to identify the reasons they did not or could not bridge. These potential findings may help to identify programmatic solutions to bridging.

Future studies of the elements of bridging in formal and informal environments should include measures of teaching strategies used such as direct instruction, guided activities, just-in-time instruction and exploration time. These additional sources can be explored to identify the environment created by the teacher whether in the school day or in OST.

Finally, there is a need for more research about how to recruit and train informal-formal teaching teams with the intention of bridging. By identifying and training teams with the commitment and follow-through to implement bridging models with their students' future studies could use more rigorous mixed method inquiry to explain how bridges are created, implemented and maintained. Further investigation of bridging models can reveal information that will help improve the learning experiences of students in cooperative ways to increase interest and skills in STEM.

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Appendix A

Interview Questions
Research Question-Case Study
What factors facilitated a bridging model in this case?
What does bridging look like in this case?
What are the active elements/components for bridging in this case?

Interviewee Info:

- What is your current position?
- How long have you worked in this position?
- What is your academic background and experience?
- How did your background lead you to this position?
- How did you become interested in this type of work?
- How long have you worked in this field?
- What is the most challenge aspect of your work?
- What is the most rewarding aspect of your work?
- What are your duties, functions and/or responsibilities of this job role?

Informal environment

- What are the core activities in the informal learning environment?
- Describe the overall goals of the informal learning environment.
- Describe your program/activity selection strategy or method for the informal learning environment.

Bridging:

- With whom do you communicate and/or work with to determine how you will connect (bridge) the formal school content & activities with informal learning environment?
- What current or past programs or activities are you/have you connected (bridging) with the formal school content and informal learning environment?
- How much of your programming decisions are based on student content and activities during the school day?
- How did WearTec curriculum contribute to decision making for this bridge? How do you make those decisions?

Role

- What skills and knowledge are most critical for connecting the formal school content & activities with the informal learning environment?
- What do you see as the opportunities for growth and development of bridging opportunities in your program and school?

Structure

- What factors contribute to your success in bridging the informal learning environment with formal school content & activities?
- What factors would most improve your capacity to bridge the informal learning environment with formal school content & activities?
- What advice would you give other schools that are seeking to connect the informal learning environment with formal school content & activities?

Formal Teacher and Informal Teacher Specific:

- How did you and your collaborating partner establish roles and goals for the lessons of the WearTec Curriculum?
- Describe the planning phase of implementation: Who, Where, What, When, Why?
- What challenges, if any, did you need to overcome in implementing the curriculum in the informal learning environment and formal school day?
- What opportunities for implementation, if any, did you find when implementing the curriculum in the informal learning environment and formal school day?
- Describe an example scenario of what the students did during the school day and what they did in the informal learning environment when implementing the WearTec curriculum.
- How would you summarize your role in implementing the WearTec curriculum?
- How would you summarize your partner's role in implementing the WearTec curriculum?
- What was the most in effective lesson or activity in terms of engagement, content knowledge, and outcomes?

Member checking

- Describe your thoughts on the interpretation of your school's bridging practices.
- Is the biographical information of you and your school or informal learning environment correct?
- How does the overall analysis and interpretation of our interactions 'ring true?'

Appendix B

WearTec Implementation Log
Complete IMPLEMENTATION LOG after each WearTec class/club.
* Required
1 Enter Teacher's Last Name * i.e. Suess
2 Enter your School Name * i.e. AboveAverage Elementary
3 Enter Grade Level(s) taught i.e. 4th; 5-6th
4 Who taught the lesson? *Check all that apply.*
Certified Teacher
Afterschool Educator
5 In which environment was WearTec completed? * *Mark only one oval.*
Formal setting (School Day)
Informal setting (Club/Out of School Time)
6 Enter date of WearTec Club or Class * *Example: December 15, 2012*
7 Approximately how many hours were students in WearTec? * Enter time to nearest quarter-hour. *Example: 4:03:32 (4 hours, 3 minutes, 32 seconds)*
8 Which lesson was taught or students engaged in? * *Mark only one oval.*
PreTest *Stop filling out this form.*
Lesson 1: Engineering Design, circuitry *Skip to question 9.*
Lesson 2: Sewing, microcontroller *Skip to question 10.*
Lesson 3: Programming *Skip to question 11.*
Lesson 4: Quilt Block *Skip to question 12.*
Lesson 5: Design Challenges *Skip to question 13.*
PostTest *Stop filling out this form.*

Lesson 1 Activities
9 Choose which activity from Lesson 1 was completed/worked-on during this session of WearTec. * *Check all that apply.*
Act1: Engineering Design Process
Act2: Circuitry
Act3: Paper Circuits
Act4: Learning to Sew
Act5: Make A Flag

Stop filling out this form.

Lesson 2 Activities
10 Choose which activity from Lesson 2 was completed/worked-on during this session of WearTec. * *Check all that apply.*
Act1: Understanding a Microcontroller
Act2: Make a Gym Bag

Stop filling out this form.

Lesson 3 Activities

11 Choose which activity from Lesson 3 was completed/worked-on during this session of WearTec. * *Check all that apply.*

- Act1: Cup Stacking
- Act2: Getting Set-up
- Act3: VibeBoard
- Act4: LED's
- Act5: RGB Tri-color
- Act6: BuzzerBoard

Stop filling out this form.

Lesson 4 Activities

12 Choose which activity from lesson 4 was completed/worked-on during this session of WearTec. * *Check all that apply.*

- Working On Quilt Project
- Quilt Presentations

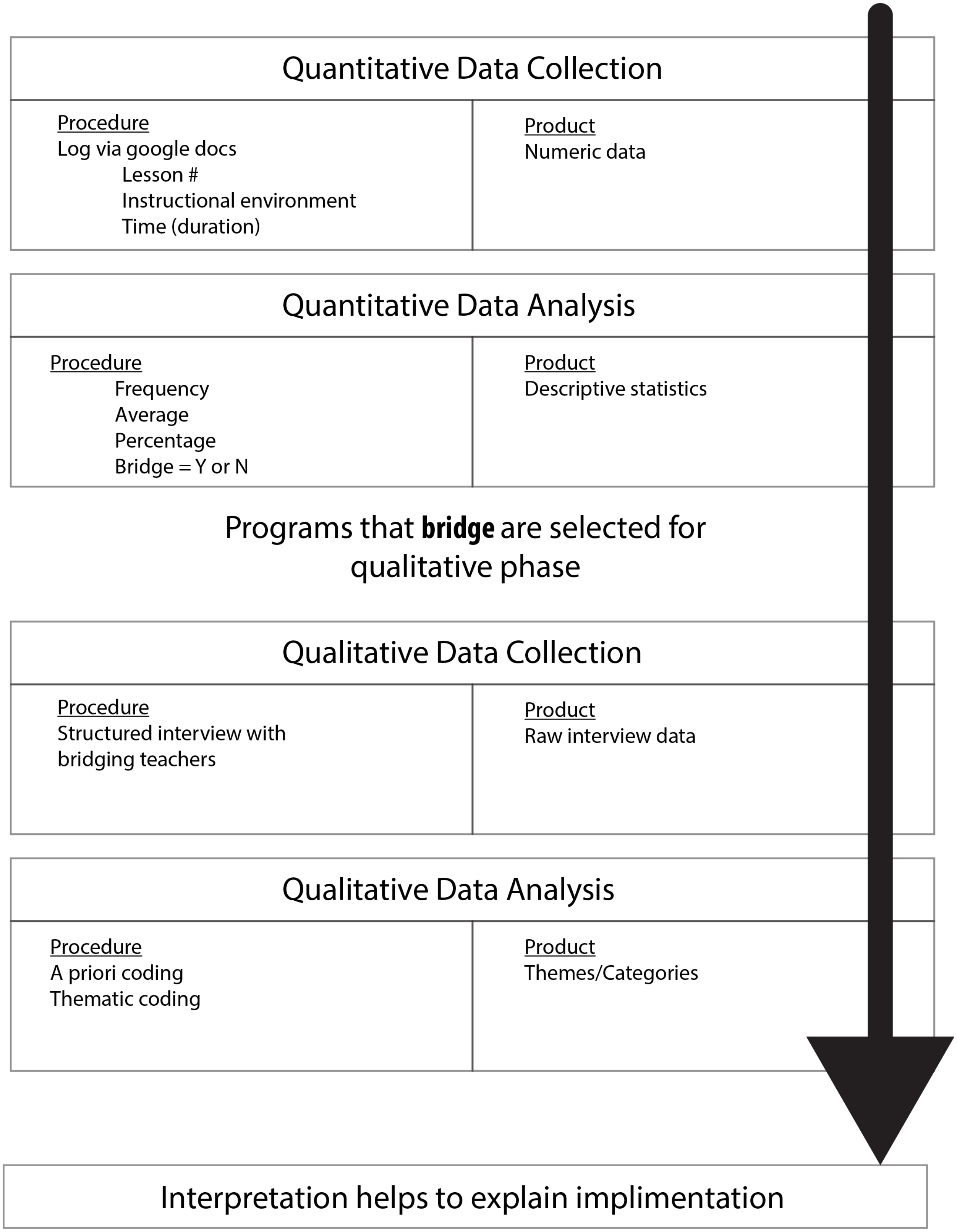
Stop filling out this form.

Lesson 5 Activities

13 Choose which activity from lesson 5 was completed/worked-on during this session of WearTec. * *Check all that apply.*

- Programming: Conditional Statement
- Programming: Light Sensor
- Research
- Engineering Design Project
- Project Presentations

Appendix C


Quantitative Data Collection
Procedure
Log via google docs
Lesson #
Instructional environment
Time (duration)
Product
Numeric data
Quantitative Data Analysis
Procedure
Frequency
Average
Percentage
Bridge = Y or N
Product
Descriptive statistics
Programs that bridge are selected for qualitative phase
Qualitative Data Collection
Procedure
Structured interview with bridging teachers
Product
Raw interview data
Qualitative Data Analysis
Procedure
A priori coding
Thematic coding
Product
Themes/Categories
Interpretation helps to explain implimentation

Appendix D

IRB# 20140314128COLLA
Date Approved: 04/05/2016
Valid Until: 03/21/2017

Know how. Know now.

Dear Wearable Technologies Participant:

We want to know what you think about wearable technologies in general and your interest in certain subjects like science, technology, engineering, and mathematics (STEM). By reading this notice and complete the project you are telling us you want to be included in the study.

You will be asked to complete a short paper and pencil survey before the project begins that will take about 20 minutes of your time and another short survey after the project is complete that will also take about 20 minutes of your time. You may also be asked to participate in a short interview (5 – 10 minutes) to provide information about learning about wearable technologies both during and after school.

You do not have to be in this study if you do not want. You do not have to do this if you do not want to or you can stop at anytime.

If you don't want to participate in the study you can still participate in the wearable technologies activities.

Sometimes participants have questions or concerns about their rights. In that case, please contact the UNL Institutional Review Board at 402---472---6965 or irb@unl.edu

If you do not wish to participate in this study or have any questions about this survey, please contact your County Extension office or the investigator of this study, Dr. Bradley Barker at 402---472---9008 or bbarker@unl.edu. Thank you for your time and interest it is greatly appreciated.

Sincerely,

Bradley Barker, Ph.D.
4---H Youth Development Specialist
State 4---H Office
114 Agricultural Hall
Lincoln, NE 68583---0700
402---472---9008

Appendix E

Structured Interview Questions

Q1 What is your instructional background and how did you get involved with WearTec?

Q2 What was your overall vision for using the WearTec activities and how they might contribute to student learning?

Q3 What activities did you do related to the WearTec program?

Q4 In general, how much time did it take you to complete each lesson? Do you feel like you needed more or less time for the lessons than was specified in the curriculum?

Q5 What did you like about the curriculum?

Q6 What improvements could be made to the curriculum?

Q7 As a teacher, what would help you to teach parts of this curriculum during school hours or what challenges do you see in trying to implement the program both during the school day and in an after school program?

Q8 What recommendations od you have for a project team to build or strengthen partnerships between formal educators during the school day and informal educators afterschool to attempt to create the program as a bridge?

Q9 Do you have anything else to mention that would be helpful moving forward with the project for next year?

Appendix F

Nebraska
UNIVERSITY OF
Lincoln

Official Approval Letter for IRB project #14128 - Change Request Form

April 12, 2016 - official approval letter

Bradley Barker
4-H State Office
AGH 114, UNL, 68583-0700

Gwen Nugent
Nebraska Center for Research on Children, Youth, Families and Schools
MABL 216F, UNL, 68588-0235

IRB Number: 20140314128COLLA
Project ID: 14128
Project Title: Wearable Technologies Project

Dear Bradley:

The Institutional Review Board for the Protection of Human Subjects has completed its review of the Request for Change in Protocol submitted to the IRB.

The change request form has been approved to implement the following change(s) and procedures as described in the form:

Implementation of interviews with member validation with Miller Park leadership and WearTec teachers.

Date of review and approval: 4/5/2016

The stamped and approved informed consent/assent form(s) has been uploaded to NUgrant. Please use the stamped form(s) to make copies to distribute to participants. If changes need to be made, please submit the revised form to the IRB for approval prior to use.

We wish to remind you that the principal investigator is responsible for reporting to this Board any of the following events within 48 hours of the event:
* Any serious event (including on-site and off-site adverse events, injuries, side effects, deaths, or other problems) which in the opinion of the local investigator was unanticipated, involved risk to subjects or others, and was possibly related to the research procedures;
* Any serious accidental or unintentional change to the IRB-approved protocol that involves risk or has the potential to recur;
* Any publication in the literature, safety monitoring report, interim result or other finding that indicates an unexpected change to the risk/benefit ratio of the research;
* Any breach in confidentiality or compromise in data privacy related to the subject or others; or
* Any complaint of a subject that indicates an unanticipated risk or that cannot be resolved by the research staff.

This letter constitutes official notification of the approval of the protocol change. You are therefore authorized to implement this change accordingly.

If you have any questions, please contact the IRB office at 402-472-6965.

Sincerely,

Rachel Wenzl, CIP
for the IRB

Full Accreditation