Teachers’ Purposeful Design of Effective Technology Learning Activities

A dissertation submitted in partial satisfaction of the requirements for the degree Doctor of Education

in

Teaching and Learning

by

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2014
The Dissertation of John Andrew Kerlin Morgan is approved, and it is acceptable in quality and form for publication on microfilm and electronically:

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Chair

University of California, San Diego
2014
Dedication

In recognition of all those who have helped me complete this with their time, support, and love. Thank you.
Epigraph

“The world belongs to those who do their homework.”

Dr. John Hunt, Ed.D.
# Table of Contents

Signature Page ........................................................................................................ iii

Dedication ............................................................................................................... iv

Epigraph ................................................................................................................. v

Table of Contents .................................................................................................... vi

List of Figures ......................................................................................................... ix

List of Tables .......................................................................................................... x

Acknowledgements ............................................................................................... xi

Vita ........................................................................................................................... xii

Abstract of the Dissertation ................................................................................... xiii

Introduction ............................................................................................................. 1
  Overview ............................................................................................................... 1

Theoretical Framework ......................................................................................... 2

Research Questions ............................................................................................... 9

Literature Review ................................................................................................. 11
  Overview ............................................................................................................. 11

Technology in the Classroom .............................................................................. 11

Human-Computer Interaction ........................................................................... 18

HCI and Activity Theory ..................................................................................... 20

Activity Interfaces ............................................................................................... 22

Activity Theory .................................................................................................... 23

Summary ............................................................................................................... 23

Methodology ......................................................................................................... 25
Overview........................................................................................................25
Positionality .....................................................................................................25
Context.............................................................................................................26
Participants......................................................................................................27
Measures ..........................................................................................................28
Procedures.........................................................................................................31
Analysis and Findings......................................................................................35
Participant descriptions ..................................................................................35
Summary of Participant Interviews .................................................................66
Summary of GOMS Analysis .........................................................................72
Identification of Themes Among Participants ...............................................75
Interpretation of Themes .................................................................................80
Finding 1: The Teachers in this study designed technology activities that were student-centered. ........................................................................................................81
Finding 2: Technology incorporation by these teachers added to the learning goals and outcomes of the activity. ........................................................................................................82
Finding 3: These teachers focused on their students and the learning goals. ........83
Conclusion .........................................................................................................86
Why Teacher Designs and Not Technology Tools ........................................86
Extension of Activity Theory Research .........................................................88
Extension of Human-Computer Interaction Research ..................................88
Implications for Technology Activity Design ..............................................89
Implications for Technology Activity Evaluation ......................................91
List of Figures

Figure 1: The cycle of design and implementation of technology activities. ....................3

Figure 2: Teachers design user interfaces for activities by adding components of activities consistent with activity theory (Engeström, 1987) ..................................................4

Figure 3: Expanded activity theory triangle (Engeström, 1987) ..................................21

Figure 4: Teacher example of Halloween candy graphing activity created by the teacher as an example for students. ......................................................................................44

Figure 5: Occurrences of talk on enhancement as engagement in learning and deepened learning by teachers during interviews. .................................................................67

Figure 7: Teachers’ design focus for technology activities by percentage of talk of activity components. ........................................................................................................69

Figure 6: The percent of student-driven choice in technology activities designed by interview participants. ..................................................................................................73

Figure 8: Teachers focused activity design on students and how they achieve the objective of the activity ..........................................................76

Figure 9: Engeström’s Activity Theory triangle adapted to show the teachers’ design focus (Engeström, 1987) ........................................................................84
List of Tables

Table 1: The relationship of GOMS and Activity Theory in the analysis of technology activities. ..................................................................................................................9

Table 2: Summary of participant demographic information..................................35

Table 3: Summary of technology activities analyzed through the study..................71

Table 4: Summary of learning goals and tool added outcomes for activities shared by participants.................................................................75

Table 5: GOMS analysis template for administrative feedback on teacher’s technology activity design.................................................................93
Acknowledgements

I would like to acknowledge Dr. James Levin for his support as the chair of my committee. Only through his help and guidance would this dissertation ever have reached this stage. His input and experience were invaluable and insights were logical and instrumental in helping me find the hidden findings in my data.

I would also like to acknowledge my family and coworkers who supported me and listened to my thoughts even when they made no sense. I appreciate the input given and the brutal honesty when the only response possible was “I do not get a single word you just said.”

I would like to acknowledge my brilliant cohort members who struggled through this process with me and helped me with my study while continuing to discover amazing insights through their own studies.
Vita

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Abstract of the Dissertation

Teachers’ Purposeful Design of Effective Technology Learning Activities

by

John Andrew Kerlin Morgan

Doctor of Education in Teaching and Learning

University of California, San Diego, 2014

James Levin, Chair

The goal of this study was to explore how exemplary teachers design learning activities that incorporate the use of technology. Teachers at three schools in a school district in Southern California were solicited for a survey regarding their use of technology in the classroom. Based on the surveys, high and low technology implementers were identified. Seven high technology implementers were interviewed about their technology implementations and teaching practices. Teachers described a technology activity and provided teaching materials for this activity during the interview. The activities were analyzed stepwise using a qualitative Goals, Operators, Methods, and Selection rules (GOMS) user interface method, which provided a framework to analyze the individual parts in the design of the activity, and Activity Theory, which provided a framework to synthesize these parts and analyze the interactions between the multiple components of the activity. The use of these frameworks afforded the analysis of the activity in a similar way to the design process, by
looking at the components, parts, of the activity and combining components to create the whole activity. The study found that high technology implementing teachers have a purposeful design of technology activities and only implement technology tools if the technology engages students and increases learning.

Teachers participating in this study agreed that technology tools alone do not increase student learning. Teachers felt their design of the shared technology activities lead to learning experiences that enhanced student learning through engagement and in-depth learning. Teachers in this study incorporated technology to balance the type of choice in activities, add to the learning outcomes of the activities, and support students in achieving the learning goal of the activity. Teachers in this study designed technology activities with thought of not only the technology tools, but with purposeful pairings of the tools with an appropriate context to increase the effectiveness of activities as learning experiences. This study used new methods of analyzing technology activities that teachers and administrators can use to evaluate activities for reflection on and alteration of the activity for subsequent activity implementations.
Introduction

Overview

A common view of teaching is a picture of a teacher in a room with students. Regardless of the shape or layout of the room, students are engaged in a lesson or activity as the teacher instructs or facilitates an activity performed by students. This picture of teaching accounts for the implementation of learning activities, but does not depict the time the teacher spends before-hand designing lessons and activities. A more complete picture of teaching shows not only the implementation, but also the design process of the lessons and other activities that teachers use in their classrooms with students.

With the increased amount of technology in education, a view of teaching may shift to students working with technology devices in the classroom. Perhaps the visualization above has students working with computers, cell phones, or tablets to complete an activity. Like the common idea of teaching, the study of technology in education has focused on the implementation of activities rather than the design of the activities.

Research studies in schools where students use technology have focused on the implementation of technology activities. In these studies there is evidence of implementation that leads to student learning (De Jong & Van Joolingen, 1998; Looi et al., 2011; Mifsud & Mørch, 2010). Yet this has been accompanied by other studies pointing to falling test scores within these technology rich classrooms (Center on Education Policy, 2011). While researchers agree that technology can change education (Beyerbach, Walsh, & Vannatta, 2001; Gerard, Varma, Corliss, & Linn, 2011; Goldman, Black, Maxwell, & Plass, in press; Jonassen, Carr, & Yueh, 1998; Jonassen, 1984;
Lawless & Pellegrino, 2007; Merrill, 1995; Taylor & Doughty, 1988), there is a lack of consensus on the educational benefits of technology, and there are mixed findings of whether technology leads to increased student learning (Robertson, 2003). The practice of using new technology with old teaching practice, as described by Cuban (2001), depicts the presence of technology in education as “oversold and underused”. Yet there is still an educational investment in technology by educators.

This study looked at the use of technology through a different lens. The focus of this study was not on technology as an activity, but on the teacher as a designer of technology activities. From this perspective, technology activities were studied through the design of the activity rather than through the implementation. The data collected during the study focused on the incorporation of artifacts and context that teachers used and created in their classrooms to build activities in which students use technology. The premise of the study was that the teachers’ design of activities that incorporate technology affects the outcome and whether, or not, students achieve the learning goal.

**Theoretical Framework**

Activity Theory as well as user interface analysis from Human-Computer Interaction research make up the theoretical framework for the analysis of teacher designs of activities where students use technology. The purpose of using Activity Theory (AT) was to synthesize the context and tools with which students work to achieve an objective for the activity (Kaptelinin, Kuutti, & Bannon, 1995). Teachers design technology activities by structuring the context and tools for students to use during the activity (Beyerbach et al., 2001; Uden & Willis, 2001). The tools for these activities were the worksheets, computers, software, discussion groups, and assessments that that made up
the activity (Bødker, 1989). Tools alone were not the entire activity; teachers designed activities by combining tools and context, in doing so they created an activity for students to complete, to achieve an objective. The purpose of Human-Computer Interaction (HCI) methods was to analyze, in depth, the tools, community, rules, and division of labor that make up the activity (John & Kieras, 1996).

Teachers design educational activities and implement them so students will achieve an objective (Kaptelinin et al., 1995; Kaptelinin, Nardi, & Macaulay, 1999; Kaptelinin, 2013). The process of activity design and implementation leads to a learning objective set forth by the teacher. The study of activity design first requires a clear understanding of the design and implementation phases of activities. Figure 1 shows the cycle of activity design. Teachers design an activity and then implement the activity. Each iteration of implementation is preceded with a design phase in which the activity is adjusted for the next implementation.

![Figure 1: The cycle of design and implementation of technology activities.](image)

Teachers’ implementation of activities comes after the initial design of the activity. While the implementation phase focuses on how the students work in the
activity to achieve the objective, the design phase starts before teachers implement the activity and repeats between successive iterations of activity implementation through design adjustment and reflective practice. In the implementation phase, students work to complete an objective while the tools and context, designed by the teacher, help students mediate their work. While tools are worksheets, textbooks, lecture notes, or technology devices and software, the activity is the combination of several, or all, of these tools along with the work community, division of labor, and rules. The activity, designed by the teacher, is the interface that students use to accomplish an objective (as shown in Figure 2).

![Figure 2: Teachers design user interfaces for activities by adding components of activities consistent with activity theory (Engeström, 1987)](image)

Prior to implementation of an activity, teachers work to design the interface that students will use to complete the activity. Teachers combine tools such as worksheets, textbooks, technology, notes, etc. with the rules, community, and a division of labor to design an activity for students. The design of the activity is done in a way that teachers hope will lead students to the objective set forth by the teacher (Jonassen & Rohrer-
Murphy, 1999; Kaptelinin et al., 1995). To know whether the students reach the objective set forth by the teacher requires study of the implementation. To learn about the construction of the activity requires a study of the design of the activity and the tools and context combined to create the activity.

In an activity in which students use technology, how do teachers combine the tools that students use with the context? The activity does not consist of only the computer, tablet, or technology that the students use, but the combination of several tools, one of which is technology, and the context of the activity. The teacher designs the activities with consideration for the level of students, student work habits, the environment of the classroom, ancillary learning materials, and the instructions that students receive, and, in the case of a technology activity, the device or software used.

The activities that teachers design work much the same way as a user interface. A user interface is the junction between the user, in this case the student, and the program, in this case the activity. The students work in the interface of virtual and physical space to complete a task. When software designers build software, the goal is to construct an interface that allows the user to work within a space to efficiently accomplish a goal (Cho, Cheng, & Lai, 2009; John & Kieras, 1996). Teachers create activities in hopes that students will efficiently work to accomplish the specific goal of the activity and that the components of the activity will help students mediate the achievement of the goal. When software designers develop a user interface the virtual space of computers, tablets, and cell phones is the focus. When teachers design activities in which students use technology, the user interface of the activity exists in both the physical space and virtual space where students will work. In essence, teachers are interface designers for their
students, designing complex interfaces that have both a physical space in the classroom and a virtual space on the technology device. Teachers, like software designers, try to limit distractions, increase efficiency and usability with the design of the interface, and create a space that guides students through the activity. This study treats activities designed by the teacher as user interfaces and analysis of these activities are similar to methods used by researchers in the field of Human Computer Interaction (HCI).

How do researchers in HCI study user interfaces? One method of analyzing interfaces is with the Goals, Operators, Methods, and Selection rules (GOMS) method (Card, Moran, & Newell, 1983). The GOMS method studies each step of the activity performed in the user interface with each of these four parts. The goals, operators, methods, and selection rules are studied with a set of rules used to emulate the completion of a task by a person. Through this study, the GOMS model is used to study the user interface with similar models of human behavior to emulate the completion of the activity. Through the next section I will define the parts of GOMS and how they apply in the context of education and activity design.

Goals are the objectives of each step of the activity (John & Kieras, 1996). Everything that goes into the activity design and the design of the instrument has a purpose. Worksheets may be used for accountability or to formatively assess student learning through the activity. Teachers may use groups to invoke social learning through heterogeneous grouping or to divide the labor of a large activity among several students. Why is it that teachers add technology to the activity and what is the difference between the reported purpose for the use of technology and the purpose with how it relates to the rest of the tools incorporated in the design of the activity?
Operators are the components that make up the work space of the activity (John & Kieras, 1996). On a website or in a piece of software, operators are all the buttons that can be chosen or the multitude of paths a user can take while using the website or software. In education this is not much different; operators are the tools and community that teachers work with to complete the activity. While completing the activity, students will interact with the teacher, group members, worksheets, software, websites, and resources. All of these people and tools that students work with are the operators of the activity.

Methods represent the steps users must take or the constraints placed on the user by the designer (John & Kieras, 1996). In contrast to the operators and choice provided by the different artifacts in the activity, methods are the limitations of choice. Limitations can take the form of time constraints, rules, directions, or information required to complete the activity. Methods refer to the right way to complete an activity. Methods are viewed as constraints and as guides to the activity.

Selection rules define the choices users must make to navigate through the activity (John & Kieras, 1996). When choices are available and students have the ability to select more than one option as prescribed by the operators and the methods, these are the rules, norms, or information must they apply to work through the activity. The selection rules of the activity define student choice. Students must make choices while completing the activity to work through the methods, working towards the objective of the activity. Selection rules define type of choice in the activity. Choice can be instructed or prescribed through procedures, inferred through material in a tool,
reinforced through classroom norms, determined by student interest, or left to the critical thinking of students to negotiate.

The combination of GOMS and Activity Theory is not new in the field of interface design. Researchers claim that the study of the human side of Human Computer Interaction is important in understanding how a user interface functions in a particular context (Bødker, 1989, 1990; Nardi, 1996; Wright, 1999). This framework has extended the knowledge base of educational software design and distance learning programs.

In the field of education, the use of HCI has not been used to analyze educational technology activities. Computers, tablets, and cell phones have been used in classrooms for activities but have been seen as standalone tools for students to use in achieving the objective of an activity. Researchers claim there are many advantages to using technology in the classroom (Jonassen, Tessmer, & Hannum, 1999; Jonassen & Rohrer-Murphy, 1999). Researchers agree that technology can change education and have studied the use of specific technology tools in the classroom (Beyerbach et al., 2001; Gerard, Varma, Corliss, & Linn, 2011; Goldman, Black, Maxwell, & Plass, in press; Jonassen, Carr, & Yueh, 1998), but less attention has been paid to analyzing how teachers utilize technology tools for use in their own classroom. This study analyzes teachers’ designs of technology activities through a lens that aligns with the language and theory used to develop the software and devices used in these activities. To understand how teachers manipulate the technology tools incorporated in learning activities, teachers can be seen as designers of user interfaces that involve physical and the digital artifacts.
Table 1: The relationship of GOMS and Activity Theory in the analysis of technology activities.

<table>
<thead>
<tr>
<th>Step</th>
<th>Analysis</th>
<th>Synthesis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Framework</td>
<td>Goals, Operators, Methods, Selection Rules (GOMS).</td>
<td>Activity Theory</td>
</tr>
<tr>
<td>Data</td>
<td>Activity components</td>
<td>Relationship of components</td>
</tr>
<tr>
<td></td>
<td>• Goals – learning goals</td>
<td>• tools</td>
</tr>
<tr>
<td></td>
<td>• Operators – tools and community</td>
<td>• rules</td>
</tr>
<tr>
<td></td>
<td>• Methods – student mediation of learning goals.</td>
<td>• community</td>
</tr>
<tr>
<td></td>
<td>• Selection rules – student choice in activity.</td>
<td>• division of labor</td>
</tr>
</tbody>
</table>

The use of GOMS and Activity Theory allowed the analysis of the activity in parts and synthesized as a whole, as shown in Table 1. GOMS framework was applied to analyze the use of tools and context of the activity individually in the discrete steps of the activity. Activity Theory was used to synthesize these parts of the activity together to reconstruct the activity and give a picture of the activity as a whole. Each part analyzed separately afforded the analysis of the goals, operators, methods, and selection rules of each part as described prior. Then, combining the parts with Activity Theory, the activity was analyzed as a whole. This was completed to understand how the congruence of the parts of an activity affected the teachers’ perceptions of the activity.

Research Questions

The Activity Theory and Human-Computer Interaction frameworks used in this study focused on how teachers design activities that utilize technology to help students mediate learning an objective. Though the study focused on this large question, the methods of the study aim to answer the following, more specific, research questions.
1. How do high technology-using teachers design activities in which students use technology for learning?

2. How are these teachers’ design ideas realized in the user interface of the activity?

3. How does the alignment of goals and artifacts influence these teachers’ perceptions of the technology activity?

This study focused on the teachers’ designs of technology activities implemented in the classrooms by teachers. Specifically, this study focused on the design of activities that involve the student use of technology for learning. To conduct this study, teachers at three schools completed online surveys on technology use in the classroom, interviews were then conducted with select teachers from a group identified as high technology implementers, based on survey responses, and a task analysis was performed using activity materials collected during the interview.
Literature Review

Overview

The use of technology in education has become a topic of focus in education. With the focus of technology in education comes the burden of proof; does the use of technology in the classroom lead to gains in student learning and is this gain sufficient to justify the money spent on educational technology? There is a lack of research that links the use of technology in education to higher achievement among students (Robertson, 2003). The lack of proof is described by Cuban as evidence that technology is oversold to educators by large corporations with students as a target market (2001). Cuban claims that new technologies paired with old teaching practices do not utilize the benefits and capabilities of the technology present in schools (2001). Technology is too often used as a location to re-host old activities and ways of learning (Hannafin & Land, 1997). Simply providing technology for students to use does not lead to increased learning (Light, 2001). Providing meaningful experience and access to technology is required to lead to student learning (Grassl & Mingus, 2002; Guiller & Durndell, 2007; Hokanson & Hooper, 2000). Researchers have studied the quality of technology activities and the success of integration of technological tools. While research on technology in the classroom has focused on the success of specific technology implementations, this study focused on how teachers designed technology activities and how their design of these technology activities supported student learning.

Technology in the Classroom

Despite the disagreements on the benefits of technology among researchers, technology continues to be purchased by school districts (Cuban, 2001). Cognitive
scientists believe that the use of technology, specifically as a source of cognitive tools, leads to increased learning (Jonassen, Carr, & Yueh, 1998). Cognitive scientists have found uses of technology in real life applications that make operations more manageable and lead to higher productivity and learning (Hollan, Hutchins, & Kirsh, 2000; Hutchins, 1995). As technology continues to increase in use outside the classroom as a cognitive tool, there have been suggestions that technology is a cognitive tool inside the classroom (Jonassen et al., 1998; Jonassen, 1984; Jonassen & Rohrer-Murphy, 1999; Kommers, Jonassen, & Mayes, 1992).

To illustrate this point, the implementation of calculators can look very different from classroom to classroom. The use of calculators in the classroom can replace the necessity of learning certain fundamentals at a detriment to student learning, where the technology performs an operation for students (Light, 2001), or calculators can be a tool that students use to complete operations in an activity that requires students to think more deeply about process and evaluate methods of solving problems (Grassl & Mingus, 2002). In either practice, the calculator is a tool; however, the focus of the use and the role of the calculator as a tool changes from completing an activity for the students to students thinking with the aid of a calculator to complete simple tasks in an activity. This differential use of the same technology exemplifies the degree to which technology can be a crutch to replace learning or a tool to deepen learning (Jonassen et al., 1998). Such differences in technology implementation lead to different learning goals and different levels of student learning.

Though technology often means computers, there are other forms of technology that teachers use in their classrooms. While computers, regardless of whether it is a
desktop, laptop, tablet, or smartphone, are a technology component, they do not encompass all technology devices. Technological devices can take many different forms, LCD projectors, document cameras, cameras, video-cameras, audio-recorders, and many more are all examples of technologies available for use in the classroom. What defines the technology component is not only the device, but the imagination, inventiveness, and creativity that is used to implement the device in a classroom or activity (Wright, 1999). While technology can enhance instruction, it is not the device that does so. The designs of activities that incorporate technology devices makes the difference in student learning and engagement (Jonassen et al., 1998; Wright, 1999).

The next two sections review research on successful implementations of technology in the classroom. The studies show how the use of different technology tools can increase student engagement and student learning. The purpose of these sections is to illuminate that the design of activities can lead to successful technology integration in the classroom.

**Technology to Increase Engagement**

Teaching with mobile technology engages students through communication in the classroom (Mifsud & Mørch, 2010; Thomas, 2011). For example, common teacher perceptions of mobile phone use in the classroom are negative, leading to problems in instruction. Thomas (2011) notes that teachers are hesitant to use cell phones because of the text messaging capability, but this technology is the same communication form that other teachers have used to increase productive communication in their classroom. While the distractive nature of messaging is a barrier of use for some, text messaging has been
used and studied as an effective medium to promote student-to-student and student-to-teacher communication in and out of the classroom (Thomas, 2011).

The increased communication afforded by technology can lead to more student engagement (Kiernan & Aizawa, 2004; Looi et al., 2011). By incorporating cell phones as learning devices in the classroom, they become proximal learning devices outside the classroom, Kiernan and Aizawa (2004) refer to them as “intimacy in your pocket” (p. 71). This is supported through studies which implemented cell phones in the curriculum. In a 21-week comparative study of six classes in Singapore, Looi et al. (2011) found that student groups using cell phones learned concepts more effectively and retained more material as evidenced by significantly higher scores on the post-implementation test. Along with higher post-test scores, Looi et al. (2011) noted the use of cell phones during instruction developed positive student attitudes toward content and teacher attitudes toward mobile learning. This study also found that solo inquiry activities with the use of cell phones led to more self-directed learning, self-paced learning, and student initiated research (Looi et al., 2011). Zurita and Nussbaum (2004) found that student groups in a third grade class in Chile, while collaborating with cell phones, worked together more efficiently, exhibiting more directed discussions and less argumentation. Students moved more quickly through material and scored significantly better on the subsequent test.

**Technology to Increase Learning**

The use of computers in education is not simply the use of computers by students. Implementation of computers in the classroom uses software that simulates many of the structural features of the classroom. The web-based program, Web of Inquiry, is an example of such an elearning environment focused on science inquiry learning (Shimoda,
The software contains a workspace that simulates a lab environment, a question and think section that simulates a physical worksheet, and an online guide that simulates constructivist guidance by the teacher (Shimoda, 2006). The reason for this design is to emulate the classroom environment and provide students with individualized attention through the use of a guide, so students may work at their own pace. This type of technology is not unique to the Web of Inquiry website, the design and use of elearning environments shows a focus on developing multiple aspects of activities on computers (De Corte, 2001; Jonassen, 1984; Pyatt & Sims, 2012; Reeves, Herrington, & Oliver, 2002).

The implementation of the “Thinker Toys” program studied the student achievement in an inquiry environment with and without the use of technology (White & Frederiksen, 2000). While the implementation was geared at showing that students learned more through the use of the program, the results were mixed. On standardized tests, following the implementation, students in both the control group and test group scored equally well, with no significant difference in the average of the test scores of the two groups (White & Frederiksen, 2000). However, in a post-test geared at testing students’ critical thinking through inquiry, students in the test group averaged significantly higher test scores than the control group (White & Frederiksen, 2000). Students learned inquiry techniques more with the use of this technology tool.

Technology artifacts can be as effective as physical manipulatives. The use of technology as a manipulative, where students interact with the technology to alter conditions and construct models, can replace the use of physical manipulatives in the classroom with equal success (Triona & Klahr, 2003). Researchers tested fourth and fifth
grade classes in Pennsylvania, replacing physical lab materials with virtual simulations (Triona & Klahr, 2003). Through the implementation, students learned Newtonian physics, with the test group using virtual simulations and the control group using physical materials. The groups scored equally well on post-implementation tests (Triona & Klahr, 2003). The researchers noted that the despite the affordances of the technology used in the study, they limited the variable of the test group to simply changing the manipulatives from physical to virtual and did not change any of the other aspects of the curriculum (Triona & Klahr, 2003). Despite the lack of significant difference in the two groups, researchers noted further changes that could be made to the curriculum with the tool and the affects this might have on post-implementation test scores if more of the technology affordances had been used with the test group (Triona & Klahr, 2003).

Researchers have studied virtual tutor programs used to help students learn content. Much like an actual tutor, the virtual tutor is a 1 to 1 guidance program that helps students work towards a learning goal (Koedinger & Corbett, 2005). The virtual tutor can be used on a computer in the class or outside of school to help students get extra help (Koedinger & Corbett, 2005). The virtual tutor is a software based tutor, built on algorithms, which gives guidance to students based on their answers to different types of questions. The virtual, or cognitive tutor, simulates a 1 to 1 student to tutor ratio. Although not a real person, researchers have found that the use of virtual tutor systems have lead to increased learning, beyond what a student would learn in a classroom (Koedinger & Corbett, 2005). The customized guidance provides students with individual feedback unlike a whole-class setting. Although these systems have not
equaled the learning gains of 1 to 1 student to personal tutor ratio, the 1 to 1 virtual instruction helps students learn content efficiently.

**Lack of Results**

Despite the promise of mobile and computer technology use in the classroom student achievement on national test scores has not risen with the increase in technology access in schools (Center on Education Policy, 2011; Cuban, 2001; Robertson, 2003). Along with technology access, technology use in the classroom has increased. In 2009, 97% of teachers reported having computers in their classrooms every day, 69% claim to use them often during instruction (Gray, Thomas, & Lewis, 2010). While the use of technology in education has increased, standardized testing scores dropped among high school students in 2008 and 2009 (Center on Education Policy, 2011). The lack of progress paired with the increase in access to technology supports that technology access does not lead to increased learning based on the standardized tests given at the time.

Learning is not determined by the level of access to technology, but the quality of access to technology (Guiller & Durndell, 2007; Light, 2001; Warschauer, Knobel, & Stone, 2004). As researchers study student access to technology they have disagreed about what *access* means. Technology access can be defined by differential use (Warschauer, Knobel, & Stone, 2004) as well as proximity and physical use (Light, 2001). Guiller and Durndell show that physical access to technology and quality of access to technology affect student’s abilities to learn with technology (2007). In the classroom, teachers control the quality of access to technology with the activities they design and implement in their classrooms. Well-designed technology activities incorporate technology tools to enhance the activity and aid student learning. Well-
designed technology activities are examples of high-quality access to technology in which students use technology to deepen and further their learning. This begs the question, what does a well-designed technology activity look like? To analyze designs of technology activities, this study used the Goals, Operators, Methods, and Selection rules (GOMS) framework from Human-Computer Interaction research and Activity Theory to study technology activities. These frameworks were applied to technology activities that supported student learning to analyze teachers’ designs of the technology activity.

**Human-Computer Interaction**

*User Interface and technology activities*

The junction between a human and a program is the user interface. The user interacts with the user interface to make choices, move through an activity, and complete a task. While the user interface is a singular objective studied in Human-Computer Interaction (HCI) research, it is not a single entity. The user interface is a combination of the pieces of a program that a user interacts with. This is analogous to Barbara Rogoff’s description of culture as a constellation of interactions that come together to make up the culture of a group (2003). Much in the same way, a user interface is a constellation of the goals, operators, methods, and selection rules of a program that come together to make up the user interface. The space that humans work within to complete a task on a technology device such as a computer, laptop, tablet, or cell phone is a user interface.

A user interface extends beyond the technological world and into the physical world constructed by people. For example, the organization of space in a kitchen is a user interface. The placement of the oven, cabinets, and small appliances on the counters creates a space in which people can efficiently use their kitchens to complete a task of
preparing food or washing dishes. In education, teachers design user interfaces for students. Teachers design user interfaces by creating work spaces with seating charts and bringing together work spaces with tools to design activities that students complete to achieve a learning goal. These classroom user interfaces can be analyzed for efficiency in much the same way as a computer program.

In a learning activity the user interface is the constellation of interactions between the tools, community, rules, and division of labor that students work within to complete an activity. It is the junction between the activity and the students. Students interact with the user interface to complete an activity. The user interface is the compilation of tools and context put in place by the teacher, for the students to use to mediate their completion of the objective of an activity. The user interface of the activity is analyzed through reflection, by the teacher, for efficiency and a perception of the success of the activity. When teachers find a user interface structure they find to be effective, they tend to use the structure repeatedly for different activities (Cho et al., 2009).

In a technology learning activity the technology tool is incorporated in the interface. The technology is a tool that adds to the user interface and the tools that students use to complete the activity. The technology aids in processing specific tasks of the activity and facilitating the completion of the activity (John & Kieras, 1996). The interface that students work within to complete an activity requires analysis of the artifacts and context of the activity as well as the activity as a whole (Card et al., 1983).

User Interface Analysis

Software designers use theories to analyze user interfaces of software to aid designers in creating user interfaces that are more efficient and user friendly. An applied
psychology approach known as the Goals, Operators, Methods, and Selection Rules (GOMS) method is an analysis technique used in HCI for the qualitative analysis of user interfaces (Card et al., 1983; John & Kieras, 1996). Through the GOMS method, steps of a user interface are analyzed separately for their goals, operators, methods, and selection rules and then brought together to give an overall analysis of the efficiency and usability of the user interface. Though this method has been used extensively in research on user interfaces for the purpose of software design, I have found no research of this method applied to the study of educational activities.

**HCI and Activity Theory**

Activity theory is a lens used to analyze an activity by looking at the interconnected structures that make up the activity. Researchers, using activity theory, define an activity as a system of interrelated parts (Engeström, 1987; Kaptelinin et al., 1999; Kaptelinin, 2013; Kuutti, 1996). Each part of an activity affects the overall objective of the activity. These parts, namely the tools, community, rules, and division of labor lead the subject, students, to the objective, learning goal, of an activity (Jonassen & Rohrer-Murphy, 1999; Kaptelinin et al., 1995). Activity theory, as a descriptive analysis tool, provides a scaffold for relating the individual, community, and mediating tools of an activity (Militelo & Hutton, 1998). The expanded Activity Theory triangle in Figure 3 is a graphic representation of the activity system and structures that support the objective of the activity.
Figure 3: Expanded activity theory triangle (Engeström, 1987).

The activity theory triangle breaks down the activity system into factors that affect the central line of the activity, the connection of the student to the objective (learning goal). An activity is any system of structures that lead to a product of learning (Cole & Engeström, 1993; Kaptelinin, 2013). Structures of an activity designed by the teacher should support the student in reaching the objective (learning goal) of the activity. The expanded triangle in Figure 3 is an expansion of the triangle created by Vygotsky, which focused on the subject, object, and mediating tools. Engström (1987) expanded the triangle to incorporate the factor that activity systems have a human element and are situated around other individuals. Figure 3 shows the teacher design of activities. The rules, community, and division of labor associated with the activity construct the context in which the students work with the tools to achieve the objective of the activity. In this view, the activity is affected by the context and the tools associated with the activity. The addition of technology, as a tool, affects the activity system and the objective of the activity.
The strength of activity theory as a descriptive tool is the intersection of different aspects of an activity and how they support the objective. In adding technology, the tools involved in the activity change and the objective may be affected. Although goals of an activity may differ, the structure of the activity remains the same and the variability comes with how the teacher defines each part of the activity (Kaptelinin et al., 1995). In using activity theory, the goal is not to generalize or prescribe a specific structure of the ultimate activity; the goal is to study the parts of the activity to see how they affect the learning goal of that specific activity (Jonassen & Rohrer-Murphy, 1999). How does the teacher incorporate technology into the activity and account for this with the structure of the context of the activity?

**Activity Interfaces**

User Interface (UI) is the space where users interact with media to complete the objective. Though commonly reserved to describe a combination of icons, menus, and words that represent ways in which people interact with technology, Raskin (2000) expands the definition of user interface to encompass any interaction space. The UI is the space in which the subject of an activity interacts and works to complete the activity. How does this apply to schools and the classroom?

Teachers create UIs for their students to aid them in learning, much like a software engineer builds a UI so the consumer will easily navigate the constructed program. Teachers create seating charts, arrange classrooms, and decorate walls to help students receive the appropriate amount of stimulation and lessen ancillary distractions, much like the process software developers use to design user interfaces to aid users in interacting with technology to achieve a desired objective. Based on activity theory,
teachers create a context with the community, rules, and a division of labor and have students interact with tools to create an activity. This environment in which students reside is the UI for the classroom and the activities that take place there. In technology activities the UI includes the students, the classroom structure during the activity, technology resources, and any physical tools that students may use. The UI can constrain students as they move through the activity or make the activity experience more enriching, easier to follow, and promote an objective (Raskin, 2000).

**Activity Theory**

The use of activity theory in the study of technology activities shows that the context does affect the success of technology activities. Studies of technology activities mention the use of community, rules, norms, and the division of labor paired with the technology tool (Koedinger & Corbett, 2005; Looi et al., 2011; Thomas, 2011; Zurita & Nussbaum, 2004). However, while these articles mention the context of the activity, the main goal of these articles is to demonstrate the success of computer and mobile technology used in the classroom. The fact that these technologies and these activities worked in specific classrooms does not imply that they will work in all contexts. Teachers need to pair the proper context with technology tools to enhance student learning (de Jong, 2006).

**Summary**

Activity theory provides a framework to show how teachers combine the components of the activity, studied through Human-Computer Interaction, to create the overall activity. The GOMS framework affords the analysis of the individual components of the activity while Activity Theory affords the study of the activity as a
whole (Uden & Willis, 2001). The technology tool, when incorporated into an activity in the classroom, changes the objective of the activity. The influence of the technology tool may yield misleading results without consideration of the physical environment as it is part of the user interface in which students work (Bødker, 1989). While Human-Computer Interaction affords the study of the tool of the activity, activity theory affords the study of the tool and the context of the activity together (Kuutti, 1996). To get a better picture of the activity, the tool and the context are compared to view the combination of the parts of the activity and how this affects the overall structure of the activity (Jonassen & Rohrer-Murphy, 1999; Kuutti, 1996).
Methodology

Overview

This study focused on teachers who frequently implement technology activities in their classroom and how they design the technology activities they use. How do these teachers design technology activities and what can we learn from these teachers’ designs? To study teachers’ designs, data was collected through a survey, interviews, and task analyses to answer the following research questions regarding teachers’ activity designs:

Research Questions

1. How do high technology-using teachers design activities in which students use technology for learning?
2. How are these teachers’ design ideas realized in the user interface of the activity?
3. How does the alignment of goals and artifacts influence these teachers’ perceptions of the technology activity?

Positionality

Since I have been a leader in my school as a department chair and technology advisor to teachers, I chose not to conduct this study in my own school. At the time of this study, my influence and leadership responsibility did not extend beyond my school site. I was confident that in conducting this study with teachers from other schools inside my district that my position did not add bias to the study by influencing survey and interview responses. Although teachers taught inside my district, the only connection I had with them prior to this study was the proximity of our working environments. By using teachers within my district, I had a better understanding of the population and the
context where these activities took place as well as the resources available to teachers at the time.

**Context**

The study included elementary, middle, and high school teachers at three school sites in Pacific Harbor Unified School District (PHUSD). PHUSD is a district in southern California. Like many other districts, PHUSD has spent money purchasing technology and training teachers in how to implement technology in the classroom. PHUSD was a district of 54 Schools serving 52,681 students, of which the majorities were white (60.2%) and Hispanic (25.1%) ("District Enrollment by Ethnicity - Enrollment by Ethnicity for 2012-13," 2013). 7,624 students (14.5%) in the district were eligible for free and reduced lunch ("AllThingsPLC — Research, education tools and blog for building a professional learning community," n.d.).

**Selection Process**

The rationale for schools chosen for this study was convenience and target population. The convenience of PHUSD schools was based on the proximity to my school site. Schools in this district were accessible and I was well aware of the population of students and environment in which the schools were situated. The determination of three schools represented the three types of schools in PHUSD. One elementary (k-5), middle (6-8), and high school (9-12) were selected for the study to represent the range of the district age groups and the possible variances in technology implementation. Of the schools in the district, Copper Elementary School, Vanadium Middle School, and Argentum High School were randomly selected from a group of schools advertising technology programs on their respective school websites. Websites
of the schools in the district were read and separated into technology program promoting
and non-technology program promoting schools. Of the schools promoting technology
programs on their websites, one school of each level was chosen at random.

The purpose of selecting schools in this manner was to increase the probability of
including high-technology implementing teachers as reported through the survey. The
drawback to this selection process was the possibility that teachers identified as high-
technology implementers may have a lack of variability in their technology
implementations. This drawback was viewed as negligible as teachers at all schools may
share practice due to the impact of professional learning communities on shared teaching
practice.

Participants

Survey Participants

Participants in this study were a mixture of elementary, middle, and high school
teachers from three different schools in the district. All teachers at the three participating
schools received an email consisting of a welcome letter, a consent form, and a link to the
digital survey. Of the 145 teachers who received the email, 8 elementary school teachers,
8 middle school teachers, and 19 high school teachers responded for a total population of
35 participants. Teachers who participated in the survey did so voluntarily. The purpose
of the survey was to collect data from teachers and identify a group of high technology-
implementing teachers who made up the sample of interviewed teachers. Teachers who
participated in the survey portion of the data collection varied from non-technology
implementing teachers to high technology implementing teachers. The teachers who
filled out the survey represent 20 percent of the teachers from the three schools and the
levels of technology implementation reported by teachers spanned a wide range of levels of technology implementation.

**Interview Participants**

Seven high technology implementing teachers were interviewed. I used the survey to identify a group of teachers who self-reported as high technology implementers. A stratified sample of high technology implementers comprised the pool of teachers from which I selected interviewees. Due to the limitations of the population of teachers responding to the survey and the small number of schools participating in the survey, a targeted sample increased the probability that a stratified sample of high technology-implementing teachers would give responses that produced more data in line with the focus of the study (Maxwell, 2013). Random sampling would provide a representative view of the population of all teachers at these school sites, but the focus of this study was a subset of high technology implementing teachers. To increase the number of teachers in the high-technology implementing subgroup, I further used referral sampling to obtain the names of teachers, seen by their peers as technology experts. This referral process was integrated into the survey and teachers identified were added to the subgroup of possible teachers to interview. Teachers who self-reported as low implementers or non-implementers were used for descriptive statistics, but were not added to the pool of teachers to interview. In total, four elementary, one middle school, and two high school teachers were interviewed in this study.

**Measures**

This study consisted of three measures collecting both quantitative and qualitative data. The majority of the data was qualitative collected through the interview and task
analysis measures; however, quantitative data was collected from the survey and aspects of the task analysis. The three measures used in this study, presented in chronological order, were survey, artifact elicited interviews, and task analyses. Each of the three measures aimed to answer one or more of the research questions and added to the triangulation of the findings in this study.

Survey

The digital survey was the first measure used for data collection. The link to the survey, created through Google Forms, was emailed to teachers at the three participating schools. The Survey was aimed to provide demographic information about the population as well as data to determine the pool from which the stratified sample of high technology implementing teachers were selected for interviews and task analysis. Responding teachers reported on their use of technology on the Google survey, answering a combination of multiple choice, multiple selection, and open-ended questions, as can be seen in Appendix II. Teachers completing the survey had the right to choose to answer questions or not and to provide an email address if they wanted to volunteer for a follow up interview. Additionally, teachers were provided with a chance to name another teacher whom they felt was an expert in technology integration in the classroom. The goal of the survey was to determine the pool of teachers to consider for the interview phase of the research.

Artifact Elicited Interview

The second measure was the artifact elicited interview of seven teachers. Teachers were interviewed about their classroom, teaching practice, and the technology activity they chose to share. The shared activity served as the artifact that teachers used
to recall information about the design and implementation of the activity. The artifact elicited interview was a conversation regarding the technology activities a teacher wished to share. These interviews took place in the interviewees’ classroom, outside of the normal work day for teachers. In these semi-structured interviews, teachers were asked to describe their classrooms, their students, and the normal activities that take place in the classroom. Structured interview questions can be seen in Appendix II.

Following these general questions, which gave a sense of how teachers conducted their classes and how they worked with students, teachers were asked to describe the technology activities they used in the classroom, specifically the activity they brought to share. With the activity as an aid for recollection, teachers described the activities they had implemented, the changes they had made to the activities, how the activity was physically set up in the classroom, the objectives of the activities, and the learning goals for the activity. Further, teachers were asked to give information about how students were assessed and what products students submitted at the end of the activity. Questions also focused on the role of the teachers during the activity and what materials students worked with through the activity.

The artifact elicited interview questions provided more information about the activities from the teacher’s design perspective. Teachers were asked how the activity was structured and how the students worked through the activity. To get a sense of the entire context of the activity, teachers were asked to define their role while the students completed the activity. To gain a sense of the rules of the activity, teachers were asked about the rules they enforced while students were working with technology and, specifically, while they implemented this activity.
Interviews were semi structured to allow for probing into aspects of the activity or classroom setting described by teachers. The language of teachers as they described the classroom and the students was particularly important in determining how the classroom was normally run and how the teacher designed activities with and without technology. Interviews ranged from 30 minutes to 90 minutes. At the conclusion of the interview, task materials and necessary information was collected for the task analysis phase of the research.

**Task Analysis**

The final measure of the study was the task analysis. The tasks analyzed were the activities teachers shared during the interview. Task materials were emailed to me prior to the interview and recollected from the teacher at the culmination of the interview.

**Procedures**

**Survey**

The digital survey link was emailed to teachers’ school email accounts in the middle of September, two weeks after the start of the school year. Survey data collection continued for one month. During this time period, the survey link was re-sent to teachers every week, and each time more teachers responded. After an initial disappointing response from teachers, contact was made with teachers whom I had known and worked with at the high school and elementary school to garner support and aid in receiving more responses from schools.

The data from the survey, hosted on Google Drive, organized the responses in an online spreadsheet. The data in the spreadsheet was downloaded to a computer hard drive and reduced using the spreadsheet application, Microsoft Excel. Each respondent
was given an identification number. Identification numbers were integers starting at 101 and continuing numerically upwards. Analysis of the data was then split among analysis of open and close ended questions in the survey.

Close ended questions, consisting of multiple choice questions and multiple selection questions were quantified using a preliminary coding scheme for multiple choice questions and multiple response questions. Once quantified, the spreadsheet data was uploaded to the Dedoose online research tool for further analysis. The Dedoose interface provided a visual representation of the data and descriptive statistics of the survey responses.

I used the survey to find a group of high technology implementing teachers. Teachers reported their level of technology use in the classroom. Teachers who selected frequent use of technology were placed in the high technology implementing group. To expand the pool of teachers in this group I used referral sampling. Through the survey, I asked teachers who on their campus they would consider a technology expert. The teachers referred in this manner were added to the high technology implementing group. Of the teachers in this group, I contacted all through email to ask about interest in participation in the interview phase of the study. Four elementary school, one middle school, and 2 high school teachers participated in the interview phase of the study.

**Interviews**

Interview transcripts and field notes comprised the physical data collected during the interviews. All interviews were recorded with the consent of the participants. Interviews were recorded using the PCM recorder cell phone app for recording digital audio. I recorded initial reactions during the interview through field notes and following
the interview I recorded reflections of the interviews. I reviewed these notes then scanned them as PDF files and uploaded them to Dedoose where they were paired with interview transcripts and demographic data from each of the participants.

Interview recordings were uploaded to my computer and transcribed by the primary researcher using InqScribe transcription software and transcripts were saved as Microsoft Word documents. I then printed these transcripts and checked them for accuracy against the audio recording. Once revised, I uploaded the interview documents to Dedoose, online qualitative research software. Transcripts were coded several times, beginning with a priori codes and emergent codes of themes I found in the transcripts. I then used this data to analyze how teachers design technology activities and as a procedure of the technology activity the teachers shared with me. These documents were then uploaded to the Dedoose qualitative analysis program for coding and analysis.

**Task analyses**

Task documents were collected from each of the participants through email. Teachers sent documents to the researcher during the interview scheduling process. These documents were printed and brought to the interview and used as artifacts to elicit more complete responses to questions about the activities. The activities were then uploaded to Dedoose and matched with the participant.

Tasks were reconstructed and completed by the researcher who completed the task using the directions provided and information about the activity articulated by the interviewee. Analysis of the reconstructed user interface of the activity aligned with the methods of user interface analysis in Human-Computer Interaction, where the target audience of the interface is not present (Card et al., 1983). The GOMS method, applied
to technology activities afforded the study of technology activities in a step-by-step manner. Unlike previous studies using the GOMS method, this application studied activities and not just the software tools used in activities. For each step of the technology activities shared by teachers I assigned Goals, Operators, Methods, and Selection rules. To break the activity into steps, I completed each activity as described by the teacher and depicted in the activity documents. I defined a step as a part of the activity that which leads to a specific sub-goal for the activity. I recorded this goal and assigned operators, methods, and selection rules for each step of the technology activity. I assigned goals by analyzing interview transcripts where teachers mentioned multiple goals for each activity. To assign operators, methods, and selection rules I used a combination of information from interview transcripts and my completion of the assignment. I compiled the GOMS analysis data in a spreadsheet on Google Drive; these can be seen in Appendix III.
Analysis and Findings

Participant descriptions

In this section, I refer to interview and task analysis data to describe the teachers in this study and their technology activity designs. The description of the participants includes data on the teacher, design principles as described by each teacher and the teacher’s design of at least one technology activity they shared as part of the study.

Table 2: Summary of participant demographic information.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Grade Level</th>
<th>Technology Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Candace</td>
<td>Elementary</td>
<td><em>Time for Kids</em> Article</td>
</tr>
<tr>
<td></td>
<td>Grades 3 &amp; 4</td>
<td></td>
</tr>
<tr>
<td>Kelly</td>
<td>Elementary</td>
<td>Halloween Candy Graphing</td>
</tr>
<tr>
<td></td>
<td>Grades 4 &amp; 5</td>
<td></td>
</tr>
<tr>
<td>Sam</td>
<td>Elementary</td>
<td>Watershed Presentation</td>
</tr>
<tr>
<td></td>
<td>Grade 5</td>
<td></td>
</tr>
<tr>
<td>Diane</td>
<td>Elementary</td>
<td>Watershed Presentation</td>
</tr>
<tr>
<td></td>
<td>Grade 5</td>
<td></td>
</tr>
<tr>
<td>Cathy</td>
<td>Middle School</td>
<td>Country Presentation</td>
</tr>
<tr>
<td></td>
<td>Grades 6, 7, &amp; 8</td>
<td></td>
</tr>
<tr>
<td>Earl</td>
<td>High School</td>
<td>Laboratory Stations</td>
</tr>
<tr>
<td></td>
<td>Grades 9 &amp; 10</td>
<td></td>
</tr>
<tr>
<td>Jane</td>
<td>High School</td>
<td>Terrorist Event Essay and Presentation</td>
</tr>
<tr>
<td></td>
<td>Grade 10</td>
<td></td>
</tr>
</tbody>
</table>

*Candace*

Candace had a combination third and fourth grade class at an elementary school. She frequently had students use technology in preparation for upcoming assessments. This was simplified by the proximity of her class to the computer lab. Her activities had students working at computers to learn typing skills, to format
written products, to research information on the Internet, and to read articles on the computer.

Candace designed activities to teach students specific skills and also to help students learn to use computers in general. While in the computer lab, she organized the students by grade level to teach smaller groups of students the skills they needed to learn. “They really haven't had a lot of technology prior to 4th grade. Having the combo this year has been great because I'm having my 3rd graders type everything. I only have 10 of them so I can teach 10 at a time rather than 35.” (personal communication, November 14, 2013). Though Candace’s technology activities had a focus on student learning of content, they also created opportunities to teach students about appropriately using technology and the information it provides. Candace built time into her technology activities to teach students about the use of technology.

The kids are researching right now, the 4th graders, their native Californian tribe, so the Hupa's or the Miwok's. I said if you come across any images that are inappropriate because they know that Native Americans did not always wear, they were not always fully clothed, then you just pass on that image or you can tell me, but you don't make a big spectacle out of it. You don't need to bring, you don't need to draw more attention to it. Well, of course, it happened last week and it was my most immature boy in the class and he had everybody come look at the image he saw that had a native California woman, she does not have a top on of course.

Although prior to that I had a boy come to me and said there's a very inappropriate picture on one of the images. We talked about which path should he have gone. We talked about what was appropriate because not everything is blocked unfortunately. (personal communication, November 14, 2013)

Candace also used technology activities to provide opportunities for student collaboration. She recognized that some students were more familiar with technology
than other students. She taught these students general computer skills and used these students as experts who taught other students in the class the skills they knew.

I usually will train five or six kids at a time, my strongest leaders, usually they're my GATE kids on how to save onto a flash drive so that I have extra teachers in the room, or I call them experts... They were sharing ideas and they want to help each other. Not on the computer so much, but on the iPad they can do things that I can't. I'm like wait, how do I get it to play over again? I want to just keep playing. Oh you hit this button, Mrs. G. Okay...I didn't know it could do that. (personal communication, November 14, 2013)

Her use of student experts in the class supported student collaboration in the class and allowed her to work with other small groups of students on their assignments in the computer lab. Moreover, students went beyond sharing the skill of using a flash-drive and collaborating on their assigned projects.

Candace noted that her use of technology activities created a focused work environment. In her technology activities, students worked at their computers to finish their work and improve their skills with simple typing software. “If you go into the computer lab they stay focused. Today when I gave them, they were doing more research and nobody was off task. They were doing their thing and say, oh look at this, go to this site” (personal communication, November 14, 2013). The use of the technology tool by the students was engaging the students in their work as well as in collaborating with other students. In describing an individual activity of working with the typing software, she explained her reasoning for the student engagement.

In the [computer] lab they are pretty focused. When they have something to do, they want to finish it. They're not distracted by oh my friend is texting me or I have an email or any of that. Down here when we're just doing Ultrakey or we're doing typing ... they're so into it. It's a typing
program. I think they like the competition. They're trying to beat their time. (personal communication, November 14, 2013)

Her reasoning for the student engagement in using Ultrakey software was the level of fun it provided. Students were engaged while competing to beat their previous time in the different exercises. Students were learning simple keyboarding skills in the program and were engaged in the process. Though the competition was not the goal of the activity, Candace mentioned the continued use of the Ultrakey software due to student learning gains with the software.

Candace was a high technology-implementing teacher who experimented with the different uses of technology. She used the technology to teach students about effective use strategies, to engage the students in learning content, and to teach students the necessary skills to move forward in the use of technology in future classes. The activity Candace shared with me was an example of these teaching strategies.

*Time for Kids Article Activity*

Candace implemented an activity in which students read an article on African elephants on the computer and responded to questions about the article on a printed worksheet. Candace divided the students into groups through seating arrangements in the computer lab and helped students understand the reading as needed.

They'll pull up an article on there and we're teaching them how to scroll up and down. You remember because we went through that one unit? Then they have to fill out this paper based on information they're finding in the article… [The article] talked in the beginning, oh about Chad, elephants in Chad and in Cameroon and they didn't know what that meant. I had to explain that. I clarify especially for the 3rd graders and since I have two parents this year in the room, I've been working with the 3rd graders in the back of the room. (personal communication, November 14, 2013)
Candace used the article to show students how to scroll through an article. The skill of scrolling through an article was one of the technical requirements on the upcoming Common Core assessments. She used an article that related to a book they had recently finished on African elephants to relate the activity back to what they had completed in class. Students scrolled up and down in the article to read and reread sections of the article to gather information necessary to answer the questions she gave them on the printed worksheet. Since this was the first time she had read an article on the computer, she commented on how she would alter this activity through the year to prepare students for the Common Core assessment. “That might be the next step is to reverse it and then finally, by the end of the year, you should be able to do both of these things, read the article on the computer and answer the question” (personal communication, November 14, 2013). Candace talked about how, during the next iteration of this activity, she would have students read the article in print and type their answers on the computer and, further in the course, put the article and the response questions on the computer so students would need to read the article and respond to the article on the computer in the same activity.

The article activity interested and engaged students with content. Candace explained how one student who asked to write additional information down to get involved in the African elephant conservation described in the article.

Oh yeah. The kids were so interested in it. In fact, the blonde who just came in, Emily, she goes “can I write down this additional resource so I can go home” ... It was a conservation group. She goes “so I can start raising money for this group to help them with the African elephants?” (personal communication, November 14, 2013)
Through the technology activity, Candace showed how she designed activities to teach students content and skills. She used articles relevant to the material they were learning in class to help students learn the content and engage students in material that promoted interest in the subject. The use of the article on the computer provided students with practice in scrolling through the articles and reading articles for information related to the questions posed by the teacher. She talked about how the progression of the article activity would allow students to reuse these skills and add new skills with each iteration of the activity.

**Kelly**

Kelly was a fourth and fifth grade teacher in an elementary school who had been a high technology implementing teacher. Kelly self-reported frequent use of technology in the classroom and was recognized by her peers, through the survey, as a leader in technology integration in the elementary school. Activities that she used integrated the use of student response systems in class as formative assessments, the use of laptops, and frequent use of the computer lab adjacent to her classroom which contained enough computers for a 1 to 1 student to computer ratio. Her use of technology was a way to “mix up” the classroom, “[students] need to have a good balance” of technology and paper-pencil activities (personal communication, October 31, 2013).

Through her experience using technology in the classroom, Kelly has learned to create and maintain expectations of work through classroom management strategies. Not only did she have a seating chart for her classroom, but also for the students while working in the computer lab. She had high expectations for work habits and behavior that students must maintain while working with technology. She understood that “some
students will race through the activity so they can play games. So [she gives] them options.” (personal communication, October 31, 2013). Once the expectations for the activity were met, students could complete specific tasks for improving the design of their final product depending on the skill level of the student.

Kelly felt this type of “play” was closely related to discovery and learning with technology. The goal of technology implementation in her classroom was for students to learn skills. “The skills they use in high school are the skills we are teaching them here” (personal communication, October 31, 2013). To learn these skills students must be given a structured setting to experiment with the technology. Play is “one of the big things with technology. Introduce something to them… and it’s amazing what some of the kids will create on their own; just by playing around and discovering on their own” (personal communication, October 31, 2013). She further discussed her activity design through her management of expectations and student work habits.

Well, one of my kids’ favorite things to do is, I’ll give them an assignment and they rush through it because they want to play games. So, I totally get that, and so the thing for me is... This is your assignment. It needs to get done. If you get done early, you have this option, this option, and this option. And you just have to be very strict. You have to give them very strict guidelines about the expectations. (personal communication, October 31, 2013)

Kelly had strictly defined expectations and structures for the students and constantly monitored their work by interacting with students on a class-wide scale as well as an individual scale. She further emphasized the use of play and discovery with her comparison of how she designed her technology activities versus her non-technology activities.
So in planning an activity the one thing I try to remember is, teach it at a very basic level and then allow the kids to have the freedom to do it more advanced if they can. Because you don't want to overwhelm those kids who are still learning and gaining skills...Which is actually the total opposite way that I teach in my classroom. When I teach in my classroom I teach to the highest student and then support the lowest, but in the computer lab it’s a little bit different, I actually, keep it basic and then allow the kids to be creative. (personal communication, October 31, 2013)

Although Kelly was a high technology-implementing teacher, she did not consider herself a technology expert. Her style of designing technology activities had inspired change in activities from year to year. In her description of a Halloween candy graphing activity, she described how she learned from her students and how that affected the changes in the activity in subsequent years.

I wasn't very educated in the way Excel works. I had just done basics myself. So the first time I taught it, we did it very basically. So actually, what I noticed is, as I went in the 2nd year, the 3rd year, I learned even more about what they can do and I was able to pass that on to my kids. (personal communication, October 31, 2013)

Kelly used student interest and knowledge to increase the productive interaction between students. Kelly was able to work with groups of students and to choose other students to help teach skills to the students who were not as familiar with technology. Students volunteered to help others with small tasks such as saving information to a USB flash drive.

I actually find that the kids help each other or if I am busy with someone and someone has a question, I'll say “hey who can help.” Some of the kids are still learning in 4th grade, how to save things on a flash drive. So if I'm busy helping someone I will say “ok, who can be my expert, who knows how to save on a flashdrive?” And of course 12 people raise their hands. “Who really, really, really knows how to save something on a flashdrive?” The hands go down and one is still up, and I have them go help and be experts. (personal communication, October 31, 2013)
**Halloween Candy Graphing Activity**

Kelly designed a Halloween candy activity where students counted their Halloween candy and graphed their results using a spreadsheet application. Students were given a homework assignment on Halloween day to count their candy prior to eating any of it. Students organized their candy into 7 different groups: chocolate, hard candy, chewy candy, lollipops, gum, and other. When students returned with their counts of candy for each category, Kelly took them to the computer lab where they sat at computers and began the graphing activity.

Kelly walked the students through the activity with the use of a teacher computer and a projector. Kelly slowly went through each step of how to enter the information into the Excel spreadsheet, insert a chart into the spreadsheet, adjust the layout of the chart to have titles for each of the graph axes and the graph itself, and change the design and type of chart that students wish to make. Kelly used the projected image of her computer as well as made-up data to walk students through this process.

Students were required to create a data table and graph, but had choices as to how it looked. Kelly explained that students had the choice of which type of graph to use, the colors on the graph, and whether or not to add clipart to the graph. Kelly said that during this process she allowed the students to walk around and look at the graphs that other students were making to see what they created. She described how students shared what they created willingly and taught other students how to add different things to their graph and change how it looked. When students were done, they printed the graph and turned them in to the teacher. Figure 4 shows an image of the teacher-generated example provided by the teacher, Kelly.
Figure 4: Teacher example of Halloween candy graphing activity created by the teacher as an example for students.

Kelly designed this activity with classroom management as the main focus. The steps in this activity were designed for individual work and selection rules for students were balanced between prescribed procedures and student choice. As discussed earlier, Kelly created this activity to teach the basic skills with Excel and to give students choices through the activity. Kelly found that students often exceeded her expectations when given this choice. Throughout the activity, students worked individually, following the teacher model on the projector and the teacher’s instructions. Knowing that she would need to stop for questions and retrace her steps, Kelly incorporated choice into this activity to provide students who were more proficient technology users to remain engaged in the activity. The expectation for the activity was that students create a chart of Halloween candy counts, by category with labels for the horizontal axis and vertical axis as well as a title for the graph. As shown in Figure 4, the students had choice in the
design of the graph. They could choose a different graph type, different colors, and different looks for the plots of the graphs. Kelly encouraged students to click through the different types of graphs to find one that they liked. By giving choice, Kelly added a dimension to this activity that allowed students to create an individual chart that looked nothing like the others in the class. Kelly claimed that students adjusted their graphs, colors, and clipart to their liking before they turned it in. She created a sense of play with the charts that allowed students to change their graphs while she helped those who were struggling with the basic steps in Excel. The addition of choice increased engagement and increase learning of the software in this activity. The activity also allowed those without a background with technology to complete the assignment successfully.

Students chose to share their graphs with others in the class when they finished. Kelly stated that students often compared their graphs with others in the room. They compared the colors, the clipart, the type of graph, and the amount of candy that each student reports they received from Halloween. This interactive part of the activity was not required, but Kelly said that many students did this as they were proud of their graphs and the amount of candy they collected.

*Sam*

Sam was a fifth grade elementary school teacher who worked to implement technology activities. Although Sam was enthusiastic about the possibilities of technology in education, he struggled with the lack of technology devices at his school. Sam’s technology activity design centered around the resources available and he designed activities to fit the technological limitations of the school. Though limited to
group activities, Sam described his ideal work environment as a space where students could work individually to gain skills prior to working in groups and sharing these skills.

I think something that would allow them to individually do things. Whatever that might be. Because we have ways of doing group things because we are limited, that’s the nature of it. But something to allow each kid to do something independently so that you can see how they do on their own on that thing, or use that tool. Then maybe what you could do, once they master that tool, then maybe you could break into groups and say ok, you're going to be in charge of this, you're going to be in charge of that. (personal communication, October 31, 2013)

Sam consciously designed activities in ways that matched the tools available with the context of the activities he implemented. In activities where jobs were divided, students shared computers, took turns working on their task, created products in small groups and then brought their products together to create the larger group project. Sam designed activities this way to increase the engagement of students.

They definitely are engaged, and they get into groups and boom, the next thing you know, they are constantly focused. There are a couple of kids that might be off... zoning off or goofing around, but they definitely are, you are definitely bringing the kids in. Because that’s what they are used to. That’s what they know now, is technology. (personal communication, October 31, 2013)

Sam recognized the use of technology tools as a source of engagement among students. Through the cameras, video, computers, LCD projectors, and document cameras, he found tools that students thought were “cool” to use in the classroom. He harnessed the engagement students developed with the technology tools to get students involved in projects and engaged students in learning with these “cool” technology tools. For example, Sam modified book reports in his class to be more engaging through the use of technology. Student interest in technology tools shaped his design of activities
so students had the choice to create videos and presentations rather than limiting student created products to written reports. He claimed that these products still incorporated the use of valuable information from the books they read into the multimedia book reports.

I say, do a trailer, a movie trailer or do a PowerPoint on the book that summarizes it. So now the kids are getting into it. I went from like maybe 1 a few years ago, then it became like 2, and then now I’ve got like 8 kids on board. But again, if I had something that I could borrow or if I was able to really push it with technology I think I would get more buy-in because it’s really cool. The kids are always like, oh that’s great. And they get really into it and then they have all the stuff written on there, so it’s not like it’s all pictures or music. (personal communication, October 31, 2013)

While activity theory describes tools as a way in which students use to achieve an objective, Sam described technology as a bridge to student learning. “Apply the technology as a bridge between what they are learning and what is in their life. That’s pretty much what it’s used as, like a bridge. I’m trying to think of a term, I think bridge is application. Applied versus the conceptual I guess” (personal communication, October 31, 2013). Sam implemented technology activities to get students to learn to use tools they were excited about, tools they might actually use outside of class. His focus on the development of engaging activities was evidence of the design principles he utilized in choosing tools to incorporate in the activities he created.

Watershed Presentation Activity

Sam shared an activity that engaged students through the use of technology and non-technology tools. The watershed project was a large activity that culminated with a presentation at the Ocean Institute to professional scientists and a public audience. The presentation was the final step in a month long project. Students began the project with a
field trip to the Ocean institute where they went on a boat and collected data about local sea life, pollution, and the effect of pollution on life in the ocean. Using this data, students worked to develop a question they could answer with data they could collect from their watershed.

Students worked in groups to create questions about their local watershed. In the past, they had asked about the water quality of drinking fountains at their school, in the creek that runs by their school or the local lake nearby. Students then collected samples, took pictures, and completed water quality tests on the samples they collected using water sample kits provided by the Ocean institute. Students worked in large groups and Sam helped to divide the labor among the groups and asked questions that helped students in the data collection and sample analysis process.

When the analysis was complete, students worked as a class to design and create a presentation of their study. Student, in groups of two, created sections of a Powerpoint presentation that were then brought together to form a larger presentation. Sam held practice presentation sessions where students learned to present the study on their watershed and discuss their findings. The project was teacher guided, student driven, and the product was created solely by students.

I show them at the beginning, I tell them, make sure you are detailed at what you did from beginning to end and then what will happen is I don't say anything and then we do a practice presentation and they can't move to the next one because they forgot something and I say, ok, so when we go back to the lab you need to make sure you insert that. Write that down. I kind of let them slip a little bit before. I don't just try to finish it off because otherwise they won't ever remember for next time when we do these things. (personal communication, October 31, 2013)
At the end of the project, students presented to a panel of scientists at the Ocean Institute. Students must be engaged throughout the process and knowledgeable of the material as they all had a part in the presentation. Each student presented the part of the presentation they created. Students further exhibited their learning in a question and answer portion of the presentation where scientists asked students questions about the project, the experiment they conducted, and their findings.

The watershed project engaged students through the use of choice, and authenticity of the experiment and audience. Students had a choice in the research question they posed as a class. Students worked to come up with a research question that they were interested in, as well as one that could be answered through data collection of local water. Students proposed questions about water sources near their school or in the local area. These were water sources that all students were familiar with which made the data collection simple and the results interesting to the students. The experiment was authentic as students used actual water testing kits and obtain real results of water sources. Students were in charge of collecting water samples in places they knew they could access the water easily and safely. Finally, the audience was not made up of the members of the class, but a group of scientists at the Ocean Institute who were professional scientists who worked in water quality.

Sam designed this activity with both teacher directed and student lead procedures for students to follow. Prescribed procedures came after student choices of what to question and what to test. Sam created engagement by having students choose questions that were important to the students themselves, then prescribing methods of testing these questions. Students worked diligently to collect data, test the question using water test
kits, and display the information they collected in a Powerpoint presentation. Not only were the students engaged with the experience, they were engaged with the content. Students were held accountable by their teacher, who had certain expectations for each group, and their class, who relied on each group for a complete presentation.

Sam incorporated technology to improve the appearance of the presentations of the experiment. Without the use of Powerpoint or other presentation software, students would not be able to present the material at the Ocean Institute, to an authentic audience. The use of technology improved the activity by having students find an effective way of displaying their experiment so others could learn what the class had done and share interest in the results.

Diane

Diane was a fifth grade elementary school teacher who frequently incorporated technology in activities to help students develop skills with technology and make lessons that were more relevant for students. While designing technology activities, Diane balanced the importance of technology incorporation with the educational and maturity level of her students. “They're not mature enough. That is a huge factor on how far you can go with technology” (personal communication, November 14, 2013). Through the interview Diane described the maturity level of her students as a major impediment to technology implementation in her classroom. Her class had an abnormally large number of students with behavior issues and students who lacked maturity. Diane’s implementation of technology in activities depended on how appropriate the technology was for her students.
Diane felt that technology implementation was necessary for teaching fifth grade students, but struggled with the way in which new curriculum imposed technology on the students. Diane implemented technology in her class so there was a balance between student work on the computer and student work on paper. Her technology activities used computer space and printed documents to allow students to make notes on documents, then complete work on the computer. She reported that her balanced approach allowed students to work without technology to read and write, then, using technology, to produce a product on the computer to turn in or present. Diane felt that the Common Core assessments removed too many physical tools and assessed students on their ability to work with only virtual tools. She said that students must learn to read, write, and edit on the computer which was not appropriate for students at this level.

Well not only that, even a college student, you're going to hit print. You're not going to write an opinion piece based on scrolling through something. You know what I mean? It's the reality of it. See that's the part of Common Core that is so upsetting to me. In a way we're back where we started because in a way we're having to go back to teaching to the test… Even though we know this is not what's necessarily ... It's not reality based, but yet they're still charged with having to be assessed on that, on this method. We still have to take class time to do something that we know isn't reality based...They have to navigate through three different articles and not only that the content, like the example they showed us ...was about using monkeys for research still or something ... I forget what it was. There were words like post traumatic stress disorder...Yeah. So not appropriate. (personal communication, November 14, 2013)

Diane’s implementations of technology showed a balance of high-technological methodology and appropriate levels for her students. In commenting on a Candace’s use of an online article, Diane mentioned first how incredible the activity was, but mentioned the drawback of using the computer to access the article versus printing the article for
students. “See what we mean by going back to why technology isn't exactly necessary at this level in the sense of teaching because it would be easy for her to pull the small group with a paper in hand to help them how to read that” (personal communication, November 14, 2013). Although the article was fascinating and the teacher used the article effectively to teach students how to read an article online and respond to the article on paper, she felt that the use of the technology tool in this manner was not appropriate for students who were learning to read articles with such complexity. She further went on to mention that the Common Core assessments used a similar method and that students must learn how to scroll through articles and annotate on the computer in addition to understanding the content.

**Watershed Presentation Project**

Diane and Sam shared the same Watershed technology activity. Diane created the activity and has shared it with the other members of the fifth grade teaching team at the elementary school. The implementation of the Watershed project followed the same path for both teachers. Diane described her implementation of the project in greater detail than Sam.

That's a huge thing. That's not optional. We go to The Ocean Institute ... Now that I do have a write up, it's a letter that I write to parents and explains the whole entire project to them. What the whole steps to it. The end is a presentation. We go to The Ocean Institute. We do a field trip. They're exposed to the scientific method and to field research methods. Then that's supposed to inspire them to come back and develop their own testable question and go ahead and do an experiment using the scientific method. Then we turn around and take the data that they retrieved from this experiment, put the whole process through from beginning to end, the hypothesis, the testable question, what not, on a Powerpoint. Then we go back to The Ocean Institute and share our findings with a group of 5th graders. (personal communication, November 14, 2013)
The focus of the project was not technology. Students learned the scientific method, developed and tested questions, collected and analyzed data, and presented the project to an audience. Only one of these learning goals incorporated the use of technology, the presentation of the project. Diane commented on the student engagement and learning that took place through the presentation of the project.

They do get dressed up and they do. The kids absolutely get complimented every year. Their presentation and they own it. I don't put it together for them. You'll go there and you'll see some Powerpoints that you're like there's no way 10 year olds did this. Unfortunately it shows because they’re not ... You can see they're not invested. (personal communication, November 14, 2013)

Diane’s comment that the students owned their presentation and were invested in the presentation later defined her expression of student learning. She told that students learned science more deeply through this experience than through other methods she had tried in the past and that the activity was memorable to them. In discussing what the students learned through the use of technology in the activity, Diane claimed that students did not learn technology; they used the technology to help their presentation skills and highlight the work completed in the project.

Speaking skills, presentation skills, developing and strengthening their speaking skills, how to utilize visuals for a better presentation. Really, truly Powerpoints at the level that I'm at is really not necessarily ... The overall objective is not the delivery of content as it is for enhancing their speaking skills. (personal communication, November 14, 2013)

Much of the frustration Diane talked about with the implementation of technology in fifth grade was shown through her design of the watershed activity. Diane used technology in activities to teach skills she felt her students needed. She used technology
to help students with these skills and did so through the use of PowerPoint for the presentation of the project. Diane did not advocate for the use of technology to learn skills that students were unlikely to use in settings other than testing. Her frequent use of the term “realistic” separated what she believed were skills that students needed versus skills that students were required to use for assessment purposes.

**Cathy**

Cathy frequently designed activities that engaged students and often these activities involved some technology. As a middle school Spanish and English Development teacher, she worked to create activities that involved student use of a second language. She created activities that engaged all students and got students to use their second language in a manner that was fun and challenging at the same time. Often, there was a competitive element that required students to think quickly to answer a question in their second language. Students found participation in these activities engaging and students often volunteered for them.

Cathy described a game called Around the World. In Around the World, two students would stand and are asked a question. The first student to answer correctly would move on to challenge another student, while the student who lost the challenge would sit down and wait for another turn. The goal was to make your way all around the classroom.

We'll play around the world with quizlet. I'll do that. I'll use PowerPoint's more and have them look at pictures and my 8th graders were describing people. Like short and tall, brown hair and blonde hair, like those kinds of things, like physical descriptions. So I had pictures up on a PowerPoint that I use for comparisons. I was showing them... I think it was George Clooney and Taylor Laughtner. So, you know, old and
young, grey hair and brown hair, this person is like good looking and this person is not good looking. (personal communication, November 7, 2013)

While playing this game, students learned to describe people in their second language. Cathy also used a document camera (Elmo) to project student work so students may share what they created with the class.

They really like it when you take their work and put it up under the Elmo. Like, I did that with a kid today and then we just go over it as a class that way instead of giving them the answers orally or showing them the answers...they made these bingo cards and they colored them and I put them up on the [Elmo] and they're just like, oh put up mine, put up mine. (personal communication, November 7, 2013)

Cathy incorporated technology in small ways to involve students in classroom activities. Cathy said that her use of student work on the document camera lead to better student work and more engaged learning as students were excited about sharing their work. Cathy also said the use of teacher created Powerpoints for notes changed how students responded to notes.

But if I put it on a PowerPoint, the exact same thing I would write on the board, put it in a PowerPoint presentation with a little bit, they would take notes and they would write things down. I don't know why, I don't think it’s any different than, you know, the PowerPoint I had wasn't fancy or special… Or if I did some stuff instead of just talking through things, if I put it in a presentation and had a PowerPoint presentation to guide the class with it, they seemed more focused and more on task than if we were doing it without it. And I don't know if that has to do with my presence or not, but just something interesting. (personal communication, November 7, 2013)

The addition of technology to activities in class engaged students in learning. Cathy’s mention that students remained focused through activities and wrote more complete notes. Her use of games in the classroom engaged students and her use of projected student work increased the amount and quality of work that students
completed. These effects of technology incorporation were based on both the use of the
technology tool and the design of the activities that Cathy created. Cathy shared an
activity where students used PowerPoint and Internet resources to create presentations of
Spanish speaking countries.

*Country Presentation Activity*

Cathy shared an activity where students worked in pairs to create a presentation
on a Spanish speaking country. To complete this activity, students worked in the
computer lab to gather information on their assigned country. Students were responsible
for information about the history, flag, capital, food, people, music, and points of
interest. Cathy required students to cite their sources of information on a worksheet as
well as in their PowerPoint presentation. Students worked together to generate a list of
sources of information, the actual information, a storyboard for the presentation, and the
final presentation.

To increase student engagement, Cathy incorporated several features with the
country report. To ensure that students collaborated on the presentation, Cathy required
students to complete a storyboard on paper prior to creating the PowerPoint
presentation. In doing this, Cathy expanded the workspace beyond the computer screen
to a piece of paper that allowed more students to add to the presentation. The storyboard
was completed in class to maximize the time students had in the computer lab to
complete their presentation. The information Cathy required in the presentation aligned
with student interest as well as met the content standards for learning a second
language. Students collected information on topics they cared about in their own
country, the food, the people, and the music of the country. Finally, Cathy incorporated a
point-of-interest slide in the presentation where students added information on a topic that was interesting to the pair of students working on the country.

Cathy used the activity to help students learn about Spanish-speaking countries and develop their presentation skills. In her instructions for the activity, Cathy told students that they were to use bullet points rather than sentences and paragraphs of information. She claimed that this made it impossible for students to present by reading off their presentation and made the slides less cluttered with words, leaving room for pictures and graphics. She mentioned that this was good presentation practice and also forced students to create presentations that engaged other students more with multimedia in the presentation.

Cathy’s extensive experience in designing activities has given her experience in engaging students with information, interest, and choice. Students learned vital information about required material and were given the chance to express themselves through the choices of interest they presented to the class. Cathy planned technology activities with the same goals as her non-technology activities, with a focus on student engagement and interest that lead to student learning.

Earl

Earl was a high school biology teacher and coordinator of a school iPad academy. He taught three sections of iPad biology and one section of non-iPad biology. Earl was a self-reported high technology-implementing teacher and was identified by many teachers as an expert in technology implementation through the survey. Despite his extensive implementation of technology in the iPad academy, Earl limited his implementation of technology to ensure that all students had access to the
same type of information and learning. The main difference in the iPad academy classes was the way in which students accessed information and reported their answers to questions.

When I am planning the lesson its, what can I do with both, but also what can I let the iPad kids go off on their own and figure out themselves and have a little more hands-on than the non-iPad kids… if the non-iPad kids can't access it then there's that. And we have a cart of iPads that for my coordinated class I've wheeled in here, but there will be an activity in a couple of weeks that I will bring it in for the non-iPad kids, so if there's no access then obviously we are not going to build the lesson. (personal communication, November 5, 2013)

Earl created the iPad academy with the support of his school and district to increase authentic learning opportunities for students. His use of technology in the classroom afforded students the chance to see authentic data rather than absorb information from a teacher. The changes Earl made to his curriculum were simple, but incorporated strategies that helped students learn in a way that aligned with the Common Core State Standards and the Next Generation Science Standards (personal communication, November 5, 2013).

We just can add more, go look this up. When we're doing something there's something that we are talking about, article reading. If there's something I got that morning, they take that out, they can annotate right on there, they can write in their textbook on there. You can't write in your textbook but they can write in their textbook. All the stuff that we're supposed to be doing with Common Core, its perfect with this, but the other kids, you can't write in your textbook, you have to do sticky notes instead though. (personal communication, November 5, 2013)

With the small changes that Earl added to the curriculum, he made learning more immediate with the use of Internet resources on tablet computers. “It was a lot easier if they had the iPad. Took a picture, drew it, and were able to identify it right away versus
with the extra time to do that stuff at home” (personal communication, November 5, 2013). Students were able to immediately access information relevant to the activity they were completing and get more accurate answers to questions by studying material while it was fresh rather than having to wait until later.

Earl also created activities where students had the opportunities to share what they created with the class and inspired discussions on what students shared. The use of small student presentations involved more students in lessons by adding a collaborative component as well as an audience of peers to activities.

I have Apple TV in here which we are not supposed to have, and I have my own network, which we are not supposed to have. But the kids do, they can share whatever they’ve done. So my iPad kids, we were doing photosynthesis equation. Put yours up on the screen, let’s go over it or in some of the English classes they will put their stuff up on the screen, they can critique other people’s work. Whatever we’ve done in here we can project it and see real quickly, ok you put your up, you put yours up, you’re doing 5 and 6, 7, that’s about it. (personal communication, November 5, 2013)

Though Earl used technology activities with immediate information access, authentic audiences, and collaboration, he still designed activities in much the same way he designed non-technology activities. Earl claimed the most important aspect of these activities was the “normal teacher stuff.” Earl’s focus on activity design was the use of detailed instructions and being attentive to his students. During activities he constantly walked around to help students, listened to what students were doing and shared insights from past classes. In describing changes to a recent activity, Earl noted that his directions always needed to improve. He noted that he often goes over the lab with the students prior to the lab and that students often follow the directions he says and that better
directions would allow him to have students move directly to labs, this was something he
was not yet comfortable with doing. Earl focused on the details of teacher practice and
said that the technology tool was just a tool that helped; it was the students and the
teachers that made the activity a positive learning experience.

*Laboratory Stations Activity*

Earl shared a laboratory activity where students worked in groups and traveled to
stations around the room to gather data from microscopes. Students worked in pairs
throughout the experiment, collecting data from microscopes. In his room, he set up
seven stations on the counters lining the walls of his room. He had student groups move
from station to station with stops at their desks between stations where students could
look up information they gathered and identify the organisms they observed.

Students carried their iPads with them to the stations and back to their
seats. While at the stations, students could use their iPads to take picture of the
organisms through the microscope, they could use a stylus to draw the organisms they
observed, and they used their iPads to record information required at each lab
station. When students returned to their desks between lab stations they used the
pictures, drawings, and observations to immediately analyze the information and answer
the questions on the digital worksheet provided. At the end of the lab, students turned in
their work to the teacher’s website for grading.

The use of the iPad did not change the lab experience, but did increase student
learning in the activity with immediate access to information. With the iPad, students
were able to immediately use online reference material and images to identify organisms
they had seen. Earl also noted that students who had forgotten concepts from the notes
were able to access their notes on the iPad or look up the concepts on the Internet quickly. The use of the iPad shortened the timeline of the analysis by allowing students to complete their research between lab stations. Students analyzed the lab data one station at a time. Students in the non-iPad academy class had to collect material and rely on the notes and observations taken at every station and then wait until they went home to research their data on the Internet. The immediacy of the data analysis aided students’ learning and allowed students to gradually process information between lab stations rather than a period of data collection followed by time spent at home researching all the topics covered in the lab.

Earl limited his technology implementation to activities that both iPad academy and non-iPad academy students could complete. Though this activity was completed by both classes, the use of the iPad simplified the process and allowed students to work in a lab setting that was more realistic, where data collection and analysis happen together rather than at separate times.

**Jane**

Jane was a high school social science teacher who was a high technology-implementing teacher. She used technology for large unit projects that required students to create a digital product. She firmly believed that technology activities must be thought out and carefully designed. “Just because a lesson has technology in it does not mean it is going to be better than a lesson that doesn't have technology ... Just because something is technology doesn't make it better. So you have to always be thinking about is this actually achieving my goal in a better way or this just using technology to be cool?” (personal communication, November 12, 2013). Her use of technology in the classroom
was selective based on what was available and whether or not technology would actually make the activity “better.” Though she admitted that technology use engaged students, her use of the term “better” centered on students’ learning.

In designing her technology activities, Jane used the same design principles that she used in designing a non-technology activity. “I feel like technology is just enhancing, so it’s not like I am changing what I do whenever I use it” (personal communication, November 12, 2013). To design technology activities, Jane did not only focus on the technology tool being used, she thought carefully about the way she grouped students, how the students interacted with each other and the technology. For an activity using a virtual tour of Auschwitz Jane chose to create a learning community that encompassed the whole class. Jane created an activity that brought together a large scale tool with an appropriate large scale learning community.

I put it on the projector and then it’s really big and they can see everything… I'll stop and ask them, what does this look like to you? They can ask questions and it’s like a very discussion oriented. And they have that paper with them and it’s just to make sure they are following along. It’s like when you give video notes… And when they see their sleeping quarters and it does a 360 view, it really makes them... It sparks a lot of questions that otherwise, they never would have… Sometimes it’s kids who don't really ask a lot. (personal communication, November 12, 2013)

Her use of the projector was appropriate for stimulating a class discussion. All students were able to see the virtual tour of the concentration camp, all students could interact by asking and responding to questions, and all students had individual accountability with the worksheet of questions about the concentration camp. Satisfying
Jane’s condition that technology should only be used if it increases the effectiveness of the activity, she stated that

when we do that virtual tour of Auschwitz. In a lot of ways that is like a lot like using a textbook, but it does give them... They love that, when we do that. Because they have never seen a concentration camp. They’ve seen photographs of it, but that is like walking through and looking at the rooms. So that enhances what they are learning. (personal communication, November 12, 2013)

The video tour of Auschwitz was a good example of how Jane designed technology activities that combine thoughtful design of the context of the activity with the tools used in the activity. Jane also shared with me a large, individual activity that showed how her design shifted with the type of activity she created and the objective of the activity.

_Terrorist Event Essay and Presentation_

Jane’s world history classes were one part of the Humanitas program at her high school. Humanitas was a program that paired world history with sophomore English classes. Students in this program often completed assignments with components completed for their English class while the other components were completed for the world history class. The terrorist event activity was one of these assignments. In this activity, students completed an essay for their English class and a presentation for world history on a terrorist event taking place after 1945. Each student had a unique topic to cover and present to the class. Jane noted that this activity would not be possible without technology. “Sometimes they pick things that happened 2 or 3 years ago or 10 years ago and there's not a book they could get that from. They have to go online and read
newspaper articles from the time and sift through them and try to piece together what happened.” (personal communication, November 12, 2013).

Through the activity students collected data on their assigned terrorist event, wrote an essay on the causes and effects of the event, and presented this to the class. Students worked in the computer lab to search for information on the event, many times these searches required advanced search strategies as some events were documented more outside the United States. Students then compiled the information and determined the causes and effects of the terrorist event and fit this information into an essay template provided by the English teacher. For the world history class, students created a presentation of the terrorist event to present to the class. Jane told the students they could use one index card and that they could only have a few words per slide. The presentation must be mostly pictorial and related to the student’s spoken presentation.

The terrorist activity deepened student learning through student research and conflicting information. The design of the activity required students to not only gather information, but to make critical decisions about the data collected. The internet contains information published all over the world; students must remember this and use this to help them decipher what actually occurred in their assigned event. Jane let students use technology to find their sources and noted that this complexified the description of the event. Students found that some of the attacks were seen as terrorist attacks from one point-of-view and acts of freedom from another point-of-view. By incorporating the use of technology, students were able to find these multiple viewpoints and make critical decisions of what was a fact and what was an exaggeration. Her use of technology in this activity engaged students in working like detectives and problem solvers collecting and
analyzing multiple sources of information to come to a perceived unbiased account of a terrorist attack.

Jane created this activity with a large amount of student choice and a scripted presentation and essay format. Jane created choice by incorporating technology and the many different points-of-view and resources available to read about any particular topic. Students had choice in what to believe and what to disregard as overly biased information. Without the use of technology, sources of information would have been the adopted history textbook and the books available in the school and local library, few of which would have been relevant sources published outside the United States.

The use of technology in the presentation of the projects made the images “big” for the entire class to see rather than small images on a poster-board used in a traditional presentation. By enlarging the images that students presented using a projector, the size of the presentation was more appropriate for a large class to view than a poster presentation.

Jane designed this technology activity in the same way she designed non-technology activities. The focus of the activity was to learn cause and effect along with a historical event. Her use of structures ensured that students completed the project having studied specific information regarding the event and presented that information clearly and efficiently. Jane’s design choices for technology activities were deliberate and she carefully chose topics that required extensive searching on the Internet that produced information that required students to make critical decisions about the description of their topic. Her use of technology made this research project possible through an expanded
database of information and provided a software framework for students to present their findings with a more effective and appropriate strategy.

**Summary of Participant Interviews**

The incorporation of technology in the classroom was conditional on whether technology would add to activities. Teachers in this study, though identified as high technology implementers, did not always use technology in the classroom. They frequently mentioned their selectivity in technology incorporation. In her interview, Jane mentioned her criteria for technology use in the classroom. “Just because something is technology doesn't make it better. So you have to always be thinking about is this actually achieving my goal in a better way” (Jane, personal communication, November 12, 2013). The teachers in this study used technology when it made the activities “better.” As this was a broad term, I asked teachers what they meant by making activities “better.”

Teachers referred to student engagement and deepened learning through the technology activities they implement, specifically the ones they shared with me. All teachers mentioned student interest and focus in the technology activity, as well as deeper learning of content. In coding the interview transcripts I found that teachers mentioned enhancement of activities with technology 47 times. Though teachers frequently used the terms “enhance,” and “better” in referring to the activities that used technology, they spoke of different types of enhancement. In recoding the interview transcripts I looked for how teachers felt technology enhanced activities. Teachers described technology enhancing activities as increased engagement and increased student learning through the activity. I analyzed the code frequency of engagement and learning as they referred to
enhancing technology activities and found that teachers at different grade levels focused on the use of technology in making activities “better” differently.

Figure 5 shows the occurrences of teacher talk on enhancement of technology activities from the interview analysis. Teachers focused their discussion of enhancement on engaging students in learning and deepening learning in activities. It was clear that teachers found activities effective if they engage students and help students achieve the learning goal of the activity. Elementary and middle school teachers placed a larger emphasis on enhancement of activities through student engagement. As these teachers discussed technology enhanced activities, they focused on student work habits, interest, and focus during the activity. Elementary and middle school teachers did discuss the added learning in technology activities, but to a lesser degree. Although high school teachers mentioned engagement in learning, they had a greater focus on the use of technology for deepening student learning.
Teachers at the high school level discussed technology enhancement with a focus on student learning. These teachers placed a larger emphasis on the use of technology to help students learn more deeply through the activities than student engagement in the activity. Despite the difference in focus of technology enhancement, teacher discussed the use of technology in activities to “enhance” lessons or make them “better” as their main rationale in incorporating technology in activities. How is increased student engagement and deeper learning operationalized in the design of the activity?

As teachers discussed their designs of technology activities they focused their talk on different design aspects. Teachers discussed many of the components described with Activity Theory, but focused on how each different component complimented the other components of the activity. In coding the interview excerpts on teachers’ design of technology activities I found that teachers did not discuss technology tools the majority of the time. By analyzing the frequency of talk on design considerations I found that teachers focused design on their students and the appropriate pairing of components they used to create the activities. Figure 7 shows the percent of teacher talk on activity design.
While discussing the design of technology activities, teachers mentioned the community and appropriate pairing of the components of the activity. Teachers’ talk about community, which constituted 33% of the talk on design, centered on students working individually or in groups as well as how students collaborated through the activity. Teachers altered their designs of technology activities to fit the dynamics of the class and how students worked in the class. Teacher talk about tools, which constituted 20% of their design talk, focused on the tools students used in the activity and how they used these tools to achieve the learning goals of the activity. The second largest percentage of teacher design talk (27%), labeled “Appropriate Pairing” in Figure 7, was an emergent design principle that teachers discussed. This portion of teacher talk on design focused on the appropriateness of the technology tool with the level of the students in the class, the appropriateness of the activity with individual or group learning communities, and the pairing of all activity components to aid students in achieving the
learning goal for the activity. While designing technology activities, teachers questioned whether the tools they incorporated in the activity were appropriate for their students and the learning community used in the activity. Teachers questioned whether, or not, the tools and community were appropriate and complimented each other to help students work through the activity.

In addition to their description of their design process, teachers described their actual technology activities. I compiled data from the interviews on the technology activities shared. Table 3 is a summary of the teachers’ activities as described by each participant. Though teacher descriptions provided a general walkthrough of the activities, I conducted further analysis of the activities using the GOMS method of analysis.
Table 3: Summary of technology activities analyzed through the study.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Activity Name</th>
<th>Activity Description</th>
<th>Tools</th>
<th>Learning Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Candace</td>
<td>Time for Kids Article Activity</td>
<td>Individual, Students Read an article and respond to questions on the article</td>
<td>computer, article, printed worksheet</td>
<td>Students learn to scroll through an article on the computer to read and look for information.</td>
</tr>
<tr>
<td>Kelly</td>
<td>Halloween Candy Graphing Activity</td>
<td>Individual, Students Count Candy at home and create the graph in the computer lab</td>
<td>candy, computer, Excel software</td>
<td>Students learn to construct and format a graph in Excel.</td>
</tr>
<tr>
<td>Sam</td>
<td>Watershed Presentation Activity</td>
<td>Group, Students create, test, and present the findings of an experiment.</td>
<td>samples, water testing kits, Powerpoint, projector</td>
<td>Students learn the scientific method through authentic experimentation and speaking skills through presentation</td>
</tr>
<tr>
<td>Diane</td>
<td>Watershed Presentation Activity</td>
<td>Group, Students create, test, and present the findings of an experiment.</td>
<td>samples, water testing kits, Powerpoint, projector</td>
<td>Students learn the scientific method through authentic experimentation and speaking skills through presentation</td>
</tr>
<tr>
<td>Cathy</td>
<td>Country Presentation Activity</td>
<td>Pairs, Students gather information on a Spanish speaking country and present it to the class.</td>
<td>computer, Powerpoint, internet resources, books, worksheets</td>
<td>Students learn to research on the internet and work with a partner to design a presentation and present to the class.</td>
</tr>
<tr>
<td>Earl</td>
<td>Lab Stations Activity</td>
<td>Groups, Students move to different lab stations to gather information and research the results of experiments</td>
<td>lab equipment, iPads, internet resources, online textbook</td>
<td>Students learn to gather real data and identify cells by comparing it to information available on the internet.</td>
</tr>
<tr>
<td>Jane</td>
<td>Terrorist Event Essay and Presentation Activity</td>
<td>Individual, Students gather information on a terrorist event, write a cause and effect essay and presentation for the class</td>
<td>computer, internet resources, Powerpoint, Word, essay template</td>
<td>Students learn cause and effect through the analysis of a single event. Students learn to judge conflicting sources of information.</td>
</tr>
</tbody>
</table>
Summary of GOMS Analysis

The stepwise analysis of technology activities with the GOMS method provided additional information about the structure of technology activities. The identification of activity goals, operators, methods, and selection rules of individual steps of technology activities verified design features teachers had described through interviews and highlighted specific design features that teachers had not articulated in the interview.

Activities, along with having an overall learning goal, have sub-goals that defined each of the steps of the activities. As shown in Appendix III, I assigned Goals, Operators, Methods, and Selection rules for each step of the activities in alignment with the definitions of these components as described in chapter 2. In the following sections, I will discuss how the GOMS analysis lead to themes in teacher designs of technology activities. Analysis of the Selection rules of activities showed that these teachers designed activities student-driven choice, leading to student-centered activities. The analysis of the sub-goals of the activities showed that the addition of technology tools to activities added learning outcomes to the activities.

Student-Driven Choice in Activities with Technology

The Goals, Operators, Methods, and Selection rules (GOMS) analysis provided information about how students worked through the activity. As described in Chapter 2, selection rules are the choices that students make to work through the methods of the activity. By analyzing the selection rules students applied during the activity I found where students followed specific procedures and where they made selections based on interest or based on information they had learned previously. By counting the number of these types of choice in each activity I found there was a balance between the choices
prescribed to students and the choices students made based on interest and prior knowledge.

![Bar chart showing percent student-driven choice in technology activities designed by interview participants.](chart)

*Figure 7: The percent of student-driven choice in technology activities designed by interview participants.*

All teachers shared technology activities that had a balance of prescribed methods and student driven methods. Prescribed methods were decisions dictated by instruction or teacher modeling. Student choice included decisions based on student interest and students’ application of learned information. The height of the bars in Figure 6 depicts the percent of student-driven choice in the activity shared by each teacher. Teachers in this study designed technology activities that had between 50% and 67% student driven methods. The teachers designed these activities with student driven and prescribed methods. Students were required to make choices to navigate the activity as well as follow specific directions. Teachers increased student engagement with choices of interest and increased learning with choices that required the application of prior knowledge or learned information. Prescribed choices required students to follow specific methods to ensure that students achieved specific learning goals in the activity.
Adding Learning Goals to Activities with Technology

Teachers added student learning goals as a direct result of the addition of technology to activities. Through the interviews, teachers articulated many of the goals of the activities, yet the more specific sub-goals of the activities were not mentioned. These sub-goals were the learning goals for each step of the activity. Regardless of the omission of these goals, the process that students followed during the activities required students to learn specific information and processes, leading to learning. Some of these goals were due to the nature of the activity while others were added due to the incorporation of technology. By analyzing the activity with GOMS to learn these sub-goals, then compiling these sub-goals with activity theory, I identified learning goals added to the activities as a result of incorporating technology tools.

As described in Chapter 3, Activity Theory supports that an activity is a system of tools, rules, community, and division of labor that aids students in achieving the learning goal of the activity. By adding to the tools of an activity, the activity could support different learning goals. The addition of technology added a tool to the activities that teachers design. The addition of technology as a tool added a resource for students to use and extended what they could learn and do in the activity. Teachers in this study designed activities that incorporated technology tools, by adding technology to activities students were exposed to more, new, and relevant information and processes. The addition of technology increased learning opportunities for students. Table 4 shows the learning outcomes added to each activity as a direct result of the addition of technology tools students used in the activity.
Table 4: Summary of learning goals and tool added outcomes for activities shared by participants.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Objective or Learning Goal</th>
<th>Tool Added Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Candace</td>
<td>Scroll up and down through an article on the computer</td>
<td>Students learn about African elephants</td>
</tr>
<tr>
<td>Kelly</td>
<td>Create a graph using Microsoft Excel</td>
<td>Students learn to display information in multiple ways</td>
</tr>
<tr>
<td>Sam</td>
<td>Design and complete an experiment.</td>
<td>Collaboratively work and present to an authentic audience</td>
</tr>
<tr>
<td>Diane</td>
<td>Design and complete an experiment.</td>
<td>Collaboratively work and present to an authentic audience</td>
</tr>
<tr>
<td>Cathy</td>
<td>Learn about the culture of Spanish speaking countries.</td>
<td>Collaborate, present with real images, and gather unique information about the country.</td>
</tr>
<tr>
<td>Earl</td>
<td>Collect data from a lab and answer content questions about the lab.</td>
<td>Compare lab observations to real data and pictures of organisms.</td>
</tr>
<tr>
<td>Jane</td>
<td>Learn about historical events and the causes and effects of the event.</td>
<td>Analyze multiple viewpoints from different geographic regions.</td>
</tr>
</tbody>
</table>

Identification of Themes Among Participants

As described in chapter 3, I conducted the analysis of the participants as well as a cross-participant analysis to find themes exemplified by all the participants. The participants in this study were high technology implementers who have been successful at designing and implementing technology activities with their classes. The themes identified in this study are the common design principles teachers used to design
successful technology activities. The next sections will describe the analysis across participants in this study and the themes that arose from the analysis.

Despite the focus on technology activities and technology incorporation in this study, teachers remained focused on their students in describing their design processes. The teachers in this study centered their activity design on their students as they were designing effective learning experiences for their students. The examples the teachers shared with me were learning activities where students used technology to mediate the achievement of the learning goal. Teachers’ descriptions and the GOMS analysis of the technology activities provided evidence that teachers designed activities to create student-centered activities and to add learning goals to activities. These themes were articulated by the teacher through the interview and verified through the GOMS analysis. Through the use of Activity Theory a third theme emerged that showed that teachers focus their design of technology activities on their students and the learning objective.

Teachers in this study shared a design focus on the students in their class and the learning objective for the activity. Teachers created learning experiences to help students achieve an objective. Teachers in this study designed activities that focused on their particular students and how their students achieve the learning goal of the activity.

Figure 8: Teachers focused activity design on students and how they achieve the objective of the activity.

Teachers in this study focused their activity design on the students they taught and how they could help their students achieve the learning goal of the activity. Teachers discussed the level and skills of their students and how they used these to design
activities that were appropriate for their students. In her discussion of the Halloween
candy graphing, Kelly discussed how her use of technology changed her expectations and
teaching methods to make the technology activity more appropriate for her students.

When I teach in my classroom I teach to the highest student and then
support the lowest, but in the computer lab it’s a little bit different, I
actually, keep it basic and then allow the kids to be creative. (personal
communication, October 31, 2013)

Kelly adjusted the level of her teaching to make the activity more appropriate for
her students. Kelly mentioned throughout the interview that her students, a combination
of fourth and fifth grade students, have different proficiency levels with technology. To
make the technology activities accessible to all of her students, Kelly adjusted the level
and method of instruction.

Candace altered her technology activities to provide students with skills they will
need on future assessments. Students in the fourth grade will take the new Common Core
Standards exam on the computer. In this exam, students will read an excerpt and respond
to questions about the reading. To prepare students for this assessment, Candace
designed a technology activity to teach students to read an article on the computer. As
described earlier, Candace used this activity to teach students to scroll up and down
through the article. She later discussed how this activity influenced her design of other
activities where students would learn to type responses to articles, and later to read
articles on the computer and type responses to the articles. Students learned the skills
they need through a progression of skills building activities that are appropriate for the
level of students she teaches.
Kelly and Candace are examples of teachers changing the complexity of the activity and the tool used in the activity to fit the level of the students they taught. While all of the teachers in the study tailored their use of technology to the level of the students, Kelly and Candace were the most articulate about their thoughts of student ability level in their activity design. To help students achieve the learning goals of the activities they design, teachers incorporate tools and a community in their design to support students in achieving the learning goal of the activity.

Teachers designed technology activities by pairing appropriate tools and communities of work in alignment with Activity Theory. As with non-technology activities, some tools used in an activity lend themselves to individual or group settings while other tools can be used in either a group or individual setting. Large projected images allow viewing by larger audiences while cell phone and tablet screens allow viewing by a single person or small audience. Computer keyboards are easily used by a single person to enter information on the computer; the keyboard does not lend itself to collaborative work with all members contributing equally, however, using Google Drive allows students on multiple computers to type into a document and contribute equally to the final product. Teachers altered their technology activity design to pair tools with an appropriate community.

Cathy altered her country presentations activity to create a tool that supported collaborative groups. By incorporating a presentation storyboard, Cathy designed a way for pairs of students to contribute equally to the design of the Powerpoint presentation on a country. Cathy had students use a storyboard to design their presentation after collecting information about their country and prior to using Powerpoint presentation.
software. Students worked collaboratively on the storyboard, which was a worksheet with a set of boxes for students to add content and design slides. Though she implemented this originally to give students a chance to work on their Powerpoint while outside the computer lab, she continued to use the storyboard in subsequent implementations of the activity as students collaborated to design presentations and map out the order, layout, and design of the presentation. This simple addition of a worksheet tool to the country presentation allowed all students to contribute to the look, layout, and content in the presentations prior to assembling the presentation on the computer. Cathy mentioned in her interview that this increased the efficiency in the computer lab with the construction of the Powerpoint and that it made the presentations more inclusive of the information contributed by members in the groups.

Jane altered the size of the learning community for an activity based on the tool used in the activity. Through the interview, Jane discussed an activity that used a virtual tour of the Auschwitz concentration camp. Jane had used this activity in the computer lab and later, due to the inability to schedule computer lab time, as a class-wide walkthrough and discussion. Though not the way she had originally designed the activity, Jane felt that this was more appropriate for the activity.

I put it on the projector and then it’s really big and they can see everything… very discussion oriented. And they have that paper with them and it’s just to make sure they are following along. It’s like when you give video notes. Are you staying awake? And when they see their sleeping quarters and it does a 360 view, it really makes them... It sparks a lot of questions that otherwise, they never would have. Sometimes it’s kids who don’t really ask a lot. (personal communication, November 12, 2013).
Jane discussed how the size of the images and the videos fit with the whole class group. The whole class could see the images and they interact by asking to see a different view or ask a question about what they saw. She mentioned how students “love that.” She commented that the use of the virtual tour was “in a lot of ways that is like a lot like using a textbook” (personal communication, November 12, 2013). The tool enhanced the student experience by providing students with a closer look at the concentration camp and the large scale of the images increased the students’ engagement with the experience. Through this activity students asked questions and contributed to discussions with the rest of the class because they were all engrossed by the same images and experience. The use of the tool of projected images and the whole class learning community complemented each other in this activity.

**Interpretation of Themes**

The interview, GOMS, and Activity Theory analyses highlighted themes in teachers’ designs of technology activities. The teachers in this study were high-technology implementing teachers who shared one of their successful technology activities for analysis. Their design principles lead to the successful technology activities they shared. Through the analysis of each activity and the comparison of the seven activities total, I identified three activity design themes. Teachers’ design of technology activities was focused on the needs of students, added student choice to activities, and added learning outcomes to activities. These design themes lead me to the findings that teachers designed technology activities to create learning experiences that were student-centered, that added learning outcomes to activities through the use of technology, and
that teachers pair technology with appropriate context to aid students in achieving the learning goals of the activity.

**Finding 1: The Teachers in this study designed technology activities that were student-centered.**

The addition of student choice to activities can both engage students and add to student learning in an activity. As students move through an activity, they are faced with choices as to how to proceed. To make these choices, students apply selection rules that allow them to move through the activity toward the objective of the activity. The selection rules for these choices can be prescribed by teachers and they can be decisions made by the students based on personal interest or based on information the students have learned. The balance of these types of choices created activities that required students to complete certain tasks, engage students by allowing them to make choices that interest them, and deepen learning by requiring students to apply the information they have learned as they work through the activity. Teachers incorporate technology in activities to balance the types of choice in the activity.

**Summary**

Teachers incorporate technology in activities to balance the types of choices students are required to make. “Better” activities are those that engage and interest students as well as those that deepen learning of content through the activity. Teachers use choice to engage students by providing them with choices of interest and to deepen learning by providing them with choices where they must apply information they have learned. Teachers also make sure that students make specific choices by following directions to ensure they learn specific information through the activity.
Finding 2: Technology incorporation by these teachers added to the learning goals and outcomes of the activity.

The addition of technology tools is the addition of a resource for students to use in the activity. The additional resource used in the technology activities adds additional outcomes to activities. The activities studied incorporated technology and by adding technology teachers designed activities that created opportunities for collaboration, for additional research and learning, and for communication of learned content to the class. All teachers mentioned that the activities they shared with me could be completed without technology. When asked why they did the activity with technology, they told me that without technology the activities would be “not as good,” “archaic,” and “unrealistic.” By adding technology to activities, teachers made the activities better and more realistic. Without technology as a research tool the activity shared by Jane, the Terrorist Event Activity, would have students using old resources and limit resources to books contained in the school library. With technology, Jane’s activity allowed students to research terrorist events and articles about the event published inside and outside the United States. The number of resources and pictures available through the use of the Internet allowed students to read about the event from multiple resources with different points-of-view and required students to make choices of what was valid, invalid, and biased information. The use of technology in this activity added learning outcomes to the activity. In each of the activities shared, technology added to the learning outcomes of the activities.
Summary

Technology added to the learning outcomes of the activities. Activities use tools to give students resources to mediate their achievement of the objective of the activity. Technology, as one of the tools that teachers can add to activities, adds a resource that students can use to achieve the objective of the activity. Adding the technology tool to the activity system can add to the outcomes of the activity. All teachers in this study added learning outcomes to the activities they designed by incorporating technology in the activity.

Finding 3: These teachers focused on their students and the learning goals.

Teachers added technology to activities to aid students in achieving the learning goal of the activity. Though the activities created by the teachers in this study all incorporated technology, the focus of teacher design was not on the tool students would use, the focus of teacher design was on the students achieving a learning goal. Teachers added technology tools that would help their students achieve the learning goal in a more efficient way. All teachers in the study conditionalized the addition of technology on whether the technology made activities more efficient learning experiences. Teachers enhanced technology activities by designing activities that were more student-centered and that added learning outcomes, but these enhancements were recognized if the activity helped students achieve the learning goal. In describing the design of technology activities, teachers frequently mentioned technology tools in conjunction with the students, the work community, or the learning goal and the appropriateness of the technology tool with these activity components. Though the technology tool was seen by teachers as an important addition to the activity, teachers mentioned the value of
technology as it pertained to the students and whether or not students could use the technology tool to achieve the learning goal.

**Summary**

The assumption in Activity Theory is that all parts of an activity help the students mediate the achievement of the learning goal in an activity. The parts of an activity are the tools, rules, community, and division of labor, as shown in Figure 9. Since students work with each of these parts to complete the activity, teachers therefore should design activities with these parts in mind. Through their descriptions and the activity analysis performed in this study, I found that teachers emphasize the design of the tools and community of technology activities. Teachers in this study focused on the appropriateness of technology tools for their students and also the appropriateness of the tools and the learning community of students in the activity.

![Figure 9: Engeström’s Activity Theory triangle adapted to show the teachers’ design focus (Engeström, 1987).](image)

The diamond shape in Figure 9 is an adaptation of the expanded activity theory triangle. The rules and division of labor are lightened as teachers did not discuss these
parts of the activity very much. Teachers in this study focused on how the tools used by students in the activity and the community they were working with, whether alone or in groups, contributed to the students ability to achieve the objective, learning goal, of the activity.

The teachers in the study paired their discussion of the technology tool with the community of the activity and how these supported the students in achieving the objective. Teachers often mentioned technology tools while talking about student level of proficiency and students familiarity of the tools available to them. They further mentioned how the tools they used worked particularly well in certain settings and not as well in other settings. Teachers paired technology tools with individual, group, or whole-class learning communities to create an activity that helped the students achieve the learning goal of the activity in an efficient way.
Conclusion

This study looked at how teachers design activities in which students use technology for learning. The study examined why teachers incorporated technology and how they designed the activities that incorporate technology. The purpose of the study was to gain insight into the design process, principles teachers use to design technology activities, and the characteristics of technology activities designed by teachers. Using an Activity Theory lens and methods from Human-Computer Interaction research, the technology activities were analyzed to answer the following research questions:

1. How do high technology-using teachers design activities in which students use technology for learning?

2. How are these teachers’ design ideas realized in the user interface of the activity?

3. How does the alignment of goals and artifacts influence these teachers’ perceptions of the technology activity?

Why Teacher Designs and Not Technology Tools

Researchers do not agree on the effects of technology in the classroom. There are conflicting arguments on the use of technology in the classroom and evidence to support the claims that technology does and does not increase student learning.

One side of the argument claims that the use of technology in schools does not lead to increased student learning. With the increase in district spending on technology devices and infrastructure, researchers have studied the use of technology and the effect it has had on student learning. There is research that technology does not increase student learning and that new technology is frequently underused and misused by educators for student learning (Center on Education Policy, 2011; Cuban, 2001; Gray et al., 2010).
The research on technology use in the classroom and decreasing state test scores provides evidence that technology does not lead to increased student learning as promised (Center on Education Policy, 2011).

Another body of research provides evidence of effective use of technology in the classroom. Research provides evidence of teacher implementations, lesson studies, and device incorporation that increase student learning. These studies show evidence of specific implementations of technology that increase student learning through activities, lessons, and practice (De Corte, 2001; Mifsud & Mørch, 2010; Stefanou, Perencevich, DiCintio, & Turner, 2004; Triona & Klahr, 2003). These studies provide evidence that technology increases student learning in the classroom.

One way to reconcile these two positions is to examine teachers’ designs of technology activities and the ways these designs impact the successful use of technology in the classroom. The research opposing the use of technology in the classroom comes from large scale data sources of national test-score trends and district spending on technology infrastructure and devices (Center on Education Policy, 2011; Richtel, 2011). The research in support of technology is specific to a classroom, or an implementation that supported the use of technology in the classroom. The degree to which technology is successful in education is not based on the technology tool that districts purchase, but the ways in which teachers incorporate these tools into their classroom activities and their design for the student use of these tools. For this reason, I chose to study how teachers design technology activities and why they choose to incorporate technology in specific activities.
Extension of Activity Theory Research

Through this study, I found that teachers’ designs of technology activities take into account the factors highlighted by Activity Theory (Engeström, 1987). Teachers design activities around the central goal of having students achieve a learning goal by completing the objective of the activity. The tools and community are added to support student achievement of the learning goal for the activity. Teachers pair the tools of the activity with an appropriate work community to create an activity system that is effective in helping students achieve the learning goal of the community. The addition of technology to the activity creates a system where students have more choice as they work through the activity which engages students and deepens their learning. Finally, the addition of technology to the activity adds learning outcomes to the activity.

Extension of Human-Computer Interaction Research

The GOMS analysis method provided an effective means of analyzing the activity systems (Card, Moran, & Newell, 1983). Applying the GOMS method to the study of educational activities proved an innovative and valuable tool for analyzing technology activities in a way that mirrors how students would complete the activity. Once the activity was divided into steps, I determined the goals, operators, methods, and selection rules for each step. The goals, operators, methods, and selection rules allowed me to identify the learning goals, tools and community, procedure of the activity, and student choice for all steps in the activity. From this analysis method, I was able to see how teachers paired the tools and learning community in the activity, how technology tools added to the learning outcomes for the activity, and the amount of student choice students had in working through the activity.
Implications for Technology Activity Design

The implementation of technology is increasing in classrooms. Teachers may choose to implement technology or they may feel pressure to implement technology in their classrooms. Teachers who are new to the idea of students using technology must understand that designing an activity that incorporates technology is similar to designing an activity without technology. Teachers should continue to focus on their students and the learning goals for activities and incorporate technology that supports the goals as well as create a learning community that supports students as they use the technology. Of the teachers I interviewed, only one claimed to be a technology expert. The other teachers stated that they use the technology knowledge of their students during the activities to help those without the same technology skills work through the activities. To implement technology, it is not required for teachers to be technology experts; instead it is required that teachers become proficient in designing learning communities that allow students to share what they know and help all students achieve the learning goals.

Teachers need to learn to design technology activities in the same way they have learned to design activities with laboratory materials and physical manipulatives. There is no question that students need to have learning experiences that engage students and connect to course content. These experiences are activities. Teachers design these activities by selecting tools, creating learning communities, establishing rules and classroom norms, and dividing labor among students to achieve a learning objective. It may be helpful for teachers to learn to incorporate technology into activities in the same manner.
Technology activities are simply activities where at least one of the tools that students use is a technology tool. Rather than center the design of the activities around the use of the tool, teachers need to continue to center their activity design around their students achieving a goal. Further, teachers need to remain aware of the appropriateness of the technology tools with their students and the community structures they pair with the technology tools in the activity. Teachers fall into the trap of designing technology activities that utilize technology tools they find interesting or engaging and trying to fit a learning goal around the tool. Teachers should design activities with technology tools the same way they design activities without technology tools, with awareness of all parts of the activity and not simply a focus on getting students to use technology. Technology tools should only be incorporated in the activity if they aid students in achieving a learning goal, engage students in learning material, and deepen student learning.

To support teachers in learning to design technology activities, districts should provide teachers with professional development on designing learning activities that utilize technology as well as time for teachers to collaborate on their uses of technology. Professional development on technology would expose teachers to the types of tools available to them and allow teachers to experience the possible uses of the technology. This would inspire some teachers to create activities that incorporate technology in activities. It would help to provide teachers with collaboration time to share the activities they have designed as well as the provide accounts of the experience and what they learned from the activity.
Implications for Technology Activity Evaluation

The user interface analysis method used here (GOMS) is an innovative and effective tool for evaluating technology activities in education. Researchers studying Human-Computer Interaction (HCI) have discussed the importance of extending interface design research into education (Uden & Willis, 2001). The adaptation of the GOMS method, used in this study, provided information that teachers can use in evaluating the technology activities they integrate into their classes. The qualitative method used in this study affords the analysis of the steps of an activity and provides information on the tools, community, and level of choice provided to students through the activity (Card et al., 1983; John & Kieras, 1996). As teachers move toward creating learning experiences that align with new standards and critical thinking requirements, teachers are charged to design activities that provide students with learning experiences that require students to think and reason as they solve problems. Students must learn to think throughout the methods of the activity, and the GOMS method allows teachers to analyze the amount of thinking students must apply by analyzing the selection rules that students apply in each step of the activity.

Though commonly used in analyzing computer software, user interface analysis is a new approach to studying educational technology activities. User interface analysis allows software companies to evaluate their products more quickly than field testing their software with a small group of users. The analysis focuses on the efficiency of workflow in the software and the ease of use of the product. This same tool was used in this study to analyze technology activities without the study of student groups as a sample of users. The analysis of the steps of activities and assigning the goals, operators, methods, and
selection rules (GOMS) for each step of the activity provided data on the efficiency and complexity of activities teachers had designed. This method provides a quick analysis of activities that teachers could use to evaluate their designs of activities and allow teachers to design activities that are efficient, engaging, and that deepen student learning. By learning how to analyze technology activities, teachers can learn the structures of activities they find helpful and continue to implement activities with similar structures that tend to lead to learning in their classrooms (Cho et al., 2009).

**Further Research on the Analysis of Technology Activity Design**

In this study, the use of the GOMS method to study the technology activities provided by teachers was completed by the researcher. Further studies having teachers evaluate their own activities through the GOMS method and Activity Theory would provide more evidence on the feasibility of this method of analyzing technology activities as parts and analyzing the activity and the interrelated parts of the activity system. Studying how teachers see their activities and how they adjust activities to engage students and have students apply information throughout the steps of the activity would provide information on teacher design principles, teaching philosophy, and educational activity construction.

This research could inform districts on needed professional development for their teachers and how to better serve their population of teachers as they begin implementation of Common Core State Standards and Next Generation Science Standards.

Further research on the GOMS analysis method should focus on administrator evaluation of teachers. The use of GOMS as a tool for administrators to evaluate teacher
performance from a design perspective provides evidence that would allow administrators to provide meaningful feedback on teacher evaluations. Evaluation and discussion of how teachers design and implement activities could help teachers design more engaging activities that increase student learning.

*Table 5: GOMS analysis template for administrative feedback on teacher’s technology activity design.*

<table>
<thead>
<tr>
<th>Step</th>
<th>Analysis</th>
<th>Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Framework</td>
<td>Goals, Operators, Methods, Selection Rules (GOMS).</td>
<td>Activity Theory</td>
</tr>
<tr>
<td>Data</td>
<td>Activity components</td>
<td>Relationship of components</td>
</tr>
<tr>
<td></td>
<td>● Goals – learning goals</td>
<td>● Are the learning goals sufficient and appropriate?</td>
</tr>
<tr>
<td></td>
<td>● Operators – tools and community</td>
<td>● Do the operators of the activity support students in achieving the learning goals?</td>
</tr>
<tr>
<td></td>
<td>● Methods – student mediation of learning goals.</td>
<td>● What steps must students take to achieve the learning goals?</td>
</tr>
<tr>
<td></td>
<td>● Selection rules – student choice in activity.</td>
<td>● What are the relative amounts of prescribed and student choice?</td>
</tr>
</tbody>
</table>

Further research is required to understand whether the GOMS analysis approach is limited to the study of technology activities or useful for all activities that teachers design. If applicable to the design of activities in general, administrators would be able to identify strengths and weaknesses of educators they are evaluating and provide appropriate support to these teachers, whether in the designs of their activities or in the implementation of the activities and classroom management.

**Future Research for Teacher Development**

The teachers in this study, being high technology implementers, have found successful ways of implementing technology to help students learn. Teachers in this study shared technology activities that were student-centered. Further research is
required to see if there is a causal relationship between student-centered technology activities and the success of technology activities. What came first? Did the teachers in this study have student-centered classrooms prior to the use of technology or did the incorporation of technology help these teachers change their activities to student-centered activities? This causal relationship has implications for the structure of professional development in technology incorporation.

By answering the question of which came first, student-centered teachers or technology, we can better serve teachers in professional development for incorporating technology. If student-centered teachers are more successful in implementing technology, then professional development on technology integration should first start with a focus on helping teachers create student-centered classrooms so the eventual incorporation of technology is successful. If technology integration in the classroom helps teachers become more student-centered, then professional development should focus on putting technology devices in students’ hands to lead to successful student-centered technology activities and teacher comfort with a student-centered classroom. Research in this area could inform professional development and lead to methods that are more efficient in teaching low technology implementing teachers to incorporate technology in activities that lead to, or possibly increase, student learning.
Appendix I: Consent and Recruitment Forms

Questionnaire Recruitment Letter

Dear CUSD Teachers,

   My name is John Morgan. I am a science teacher at Capistrano Valley High School and am currently a doctoral student at UCSD. For my dissertation project, I am interested in understanding more about how teachers design technology activities. I define technology activities as learning experiences that incorporate technology use by students.

   I will be carrying out this study as a researcher from the University of California, San Diego, not as an employee of the Capistrano Unified School District. Your decision to participate in this study will not affect your employment status. Please take a look at the attached consent form for more information about safeguarding your privacy.

   If you have any questions at all regarding this project, or the questionnaire, please call me at 760-207-1778 or email me at j2morgan@ucsd.edu and I will be happy to clarify.

   I hope you will participate in this research study because your experience can be of great help to me in this work. The following hyperlink will take you to a brief online questionnaire, which you have the option of completing anonymously.

Click here to access the questionnaire.

Thank you so much for helping me with this research project.

John Morgan
Questionnaire Consent Form

UNIVERSITY OF CALIFORNIA, SAN DIEGO – Consent to Act as a Research Subject

John Morgan, Ed. D. candidate, is conducting a research study to find out more about how teachers design technology activities. The purpose of this study is to gather information on the design of technology activities from the teachers point-of-view. Your participation in this study is voluntary. You have been asked to participate in this study because you are a classroom teacher in Capistrano Unified School District. There will be approximately 200 teacher participants in the survey phase and 9 participants in the interview phase of this study.

If you agree to participate in this study, you will be asked to complete the attached survey. The data from this survey will remain anonymous and no administrative or district level staff will have access to your responses. To participate in this study, please click on the link provided and complete the survey through the Google Drive form. For most participants, this survey is the entirety of your participation.

Participation in this study may involve some minimal risks or discomforts. These include:

1. A potential for feeling discomfort, stress, boredom, or fatigue when participation in the online questionnaire. To mitigate this, the questionnaire has been field tested and revised based on feedback in order to minimize duration and the potential for discomfort, stress, boredom, and fatigue. No questions are mandatory and you are free to skip any question that you do not feel comfortable answering.

2. A potential for loss of confidentiality. I will make every effort to ensure that all of your answers will remain completely confidential. Responses will be stored on a password protected computer in a password protected file. I will remove all identifying information from documentation of the questionnaire responses. School and district names will be changed to pseudonyms. I will never use your name, school, or district in any publication or presentation. Research records will be kept confidential. Research records may be reviewed by the UC San Diego Institutional Review Board.

Because this is a research study, there may also be some unknown risks that are currently unforeseeable. You will be informed of any significant new findings. You will be told is any important new information is found during the course of this study that may affect your wanting to continue.

The alternative to participation in this study is simply not to participate. Your job and position within the Capistrano Unified School District would not be affected in any way by your decision to either participate or not participate in this study. Participation in this study is entirely voluntary. There will be no cost to you for participating in this study.

There will be no direct benefit to you from participating in this study. John Morgan, however, may learn more about how teachers design technology activities, and the educational community may benefit from this knowledge.

If you have any questions or research-related problems, you may reach John Morgan at 760-207-1778 or by email at j2morgan@ucsd.edu. You may call the UC San Diego Human Research Protections Program office at 858-657-5100 to inquire about your rights as a research subject or to report research-related problems.

Please print this page as a record of your consent document.

By filling out the survey and submitting the form you agree that John Morgan has explained this study to you and answered your questions. You also agree to participate in the questionnaire phase of the study. To elect not to participate, delete this email, no further action is necessary.
Interview Recruitment Letter

Dear Teachers,

I would like to thank you for completing the technology survey and volunteering for a follow up interview. If you are still willing to participate, I would like to look into scheduling a time to meet with you and learn more about how you include technology in your classroom. For participating in the interview portion of my study, I can offer a $20 gift card to Starbucks.

The interview will last roughly 45 minutes and I can travel to your school for your convenience. I would prefer to do these at the end of the workday, but have some flexibility due to my prep period.

If you are still interested, please respond with 3 times that work with your schedule.

Any data collected through this interview will be anonymous to everybody but me. I will use pseudonyms for the school district, the school site, and for you to protect your identity. I would also like to stress that in no way is this an evaluation, I am simply interested in how teachers put together technology activities.

For the interview, I would like you to show me one technology activity that you have done, or are planning to do with your students. Questions will focus on the activity, what you thought about the implementation, how you might change it, how did students respond to it, etc.
Interview Consent Form

University of California, San Diego: Consent to Act as a Research Subject

The Effectiveness, Design, and Purpose of Student-Centered Technology Activities

My name is John Morgan and, as a doctoral student at UC San Diego, I am conducting a research study to find out how teachers design activities where students use technology. You have been asked to participate in this study because you have experience implementing technology activities in education. There will be three teachers each at Castille Elementary School, Vista Del Mar Middle School, and Aliso Niguel High School participating in this study. The purpose of this study is to better understand how teachers design technology activities and the instructional purpose of these activities.

If you agree to be in this study, I will spend no more than 60 minutes interviewing you about a specific technology activity that you have implemented in your class this year. I will ask you to recall the structure and context of the activity and why you decided to design the activity with this structure. To assist in the interview, I will ask you to have a copy of all activity handouts you give to your students and any student work you may have that was generated from the activity. I will ask you how successful you feel the activity was and if there is anything you would change about the activity.

While I will take all possible steps to ensure confidentiality of all information obtained for this study, there is always a risk for a loss of confidentiality. I will use pseudonyms for all adult participants, the names of the schools, and the name of the school district to reduce the chance for loss of confidentiality. Because this is a research study, there may also be some unknown risks that are currently unforeseeable. Participation in research is entirely voluntary and your participation will not affect your standing in your employment. No other persons in the school or district will be granted access to any information, transcripts, correspondence, or identities obtained through this study. You may refuse to participate or withdraw or refuse to answer specific questions in an interview at any time. If you decide that you no longer wish to continue in this study, you will simply need to inform me of your decision. If I feel that you are uncomfortable with the study, I may remove you as one of my research subjects. Also, if I discover information in my research that may affect your willingness to continue participating, I will notify you.

There is no direct benefit to you from participating in this study. The investigator, however, may learn more about how teachers design student-centered technology lessons. In addition, the educational community may benefit from this knowledge by being better able to construct activities where students use technology for learning.

In compensation for your time, you will receive a $20 gift card for participating in this research. There will be no cost to you for participating in this study. If you are injured as a direct result of participation in this research, the University of California will provide any medical care needed to treat those injuries. The University will not provide any other form of compensation if you are injured. You may call UCSD Human Research Protection Program at (858) 657-5100 for more information about this or to report research related problems.
If you agree to participate, please sign below acknowledging that you have received a copy of this consent document. You may also choose not to sign and as an alternative, choose not to participate in the study.

<table>
<thead>
<tr>
<th>Your Name</th>
<th>Your Signature</th>
<th>Date</th>
</tr>
</thead>
</table>
Audio Consent Form

UNIVERSITY OF CALIFORNIA, SAN DIEGO
AUDIO RECORDING RELEASE CONSENT FORM

As part of this project, an audio recording will be made of you during your participation in the interview portion of this research project. The researcher will use the recording to transcribe the interview for data analysis. Please indicate below the uses of these audio recordings to which you are willing to consent. This is completely voluntary and up to you. In any use of the audio recording, your name will not be identified. You may decline permission to record the interview or, having consented to the recording, request to stop the recording at any time or to erase any portion of your recording.

1. The audio recording can be studied by the researcher for use in the research project.

   [Initials]

2. Portions of the transcripts of the audio recordings can be used for educational publications, reviewed at meetings, and presented in educational settings.

   [Initials]

3. The audio recording can be reviewed in university classrooms by doctoral students and faculty members

   [Initials]

You have the right to request that the recording be stopped or erased in full or in part at any time. You have read the above description and give your consent for the use of audio recording as indicated above.

___________________________  _______________________
Signature                        Date
Appendix II: Survey and Interview Questions

Survey Questions

Technology Activity Design Survey
This survey consists of 18 questions and should take between 5 and 10 minutes to complete. Please skip any question that you feel either does not apply to you or that you feel uncomfortable answering. The purpose of this survey is to collect information on how teachers design technology activities. As a doctoral student in the Teaching and Learning program at UCSD conducting a research study of Technology activities, your information will be of great help in the study.

1. I am at least 18 years of age. *
   o yes
   o no

2. How many total years have you been teaching?

3. What grade level do you teach currently?
   o elementary
   o middle school
   o high school

4. What grade levels have you taught?
   o elementary
   o middle school
   o high school
   o post secondary

5. What subjects do you teach?

6. How often do students use technology in your classroom? Select a value from a range of 0, Never, to 3, Every Class.
   Never 0 1 2 3 Every Class

7. What are students doing during the activities in which they are using technology?
   o type
   o search the internet
   o research
   o blog
   o communicate (email, etc)
   o watch videos
   o play games
   o create presentations
   o Other:
8. In addition to computers and electronic devices, what physical materials do students use during technology activities?
   o worksheets
   o textbooks
   o articles or current events
   o workbooks
   o manipulatives
   o Other:
9. What type of tools do you have students use?
   o desktop computer
   o laptop computer
   o tablet
   o cell phone
   o Other:
10. How are the technology activities you use different than the traditional, non-technology activities you use?
11. What are three things that students can learn more easily/efficiently through technology enhanced learning activities?
12. Where do you get ideas for activities that involve students using technology? websites, coworkers, etc. (please list)
13. What is your goal in implementing activities that involve technology?
   o provide information to students
   o assess students
   o online worksheets
   o connect students with material
   o collaboration
   o Other:
     o What software do you use?
       o word/pages
       o excel/numbers
       o powerpoint/keynote/prezi
       o Other:
14. What type of technology support is available at your school?
15. Who are the teachers in your school that you view as the technology experts?
16. What does this teacher do that makes them an expert?
17. Which of the following is more important?
   o Technology Literacy or Research Skills
   o Technology Literacy or Typing Skills
   o Research Skills or Typing Skills
18. Please enter your email address if you would agree to participate in a follow up interview.

By clicking submit you agree to have your responses anonymously included in the research study.
Interview Questions

Through this interview we are going to learn a little bit about you and then look at a specific activity you have used in your class this year. Please remember that anything discussed in this interview will remain anonymous.

1. Let's start by finding out a little bit about you and your classroom. Tell me a little about you as a teacher and professional.
   - Who or where do you go to for technology support at your school?
   - Outside your school?

2. Tell me a little about your classroom. If I were a fly on the wall, what would I see happening on a day to day basis?
   - Description of classroom.

3. What types of activities do you have your students do?
   - What do they look like?

4. You were selected for this interview because you have students use technology in the classroom for learning. Can you describe the different technology tools that students use in your classroom?
   - Devices
   - Software
   - Where do you get Activities?
   - Self created, modified, or borrowed?

5. Are technology activities more interactive or engaging for students? Explain.

6. When you create technology activities for students, what goes through your head in the planning process?
   - What is important
   - How do you arrange students
   - What other materials do you incorporate?
   - What are the important considerations when creating an online activity?

7. You could perform many activities with or without technology. Why do you have students use technology?
   - How would the activity be different without the use of technology?

8. What do you see as the most important consideration in creating technology activities for student learning?

9. Many teachers do not like to have students use technology as they feel that students have an easier time getting off track and accessing material that is not part of the activity. How do you respond to this?
   - What structures do you put in place and what do you hold students accountable for?

Let's take a look at the activity that we are going to look at in depth.

10. Describe it to me.

11. What was it that you wanted students to get out of this activity? Learning goals, problem solving goals, experience, etc.

12. Do you have any rules specific to activities where students use technology?
13. When you do this activity, how did you arrange the students? How were they working?
14. When you were creating this activity, what did you anticipate and what didn’t you anticipate as far as student behavior, performance, etc?
15. What resources must they use to complete the activity?
   o What was your thought process in putting together the activities and resources that students use?
16. Are there any tricks, go-to methods, or principles you use when creating or using activities like this so students work efficiently?
17. As students complete the activity, what is your role, the students’ role?
18. If you would please walk me through this activity. What is it that students actually do in this activity?
19. What is the product that students turn in or the assessment that you grade?
20. Do you have any examples of the student products that were turned in this year? Could we take a look at them? Which of these would you consider good and bad? Why?
21. How did it go?
   o Did the activity help the students meet the learning goals? With all, some or none?
   o What was successful
   o What would you change?
22. When you used this activity in your class, did you consider it successful? How was it or how wasn’t it?
23. Do you think this activity is good? Why?
24. Many teachers have commented that activities are never exactly the same from year to year. Will you do this activity next year? If so, how will you change this activity next year? Or what will you replace it with?
Appendix III: GOMS Analysis Tables

Candace

Online Article Reading and Response Activity.

<table>
<thead>
<tr>
<th>Step</th>
<th>Goal</th>
<th>Operators</th>
<th>Methods</th>
<th>Selection Rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>Read the article</td>
<td>Students learn to scroll and read an article on the computer</td>
<td>computer, teacher, online article</td>
<td>Students read the article on the computer and scroll down to view the article as they read it.</td>
<td>Teacher modelling, teacher assistance, student reading level</td>
</tr>
<tr>
<td>Read the questions</td>
<td>Students learn to use the question to figure out what information they will need.</td>
<td>worksheet, teacher</td>
<td>Students read the question they must answer from the worksheet.</td>
<td>Student reading level, teacher assistance</td>
</tr>
<tr>
<td>Scroll through the article</td>
<td>Students learn to scroll through an article.</td>
<td>computer, worksheet, online article, computer mouse</td>
<td>Students scroll up and down through the article to find information they need to answer the question.</td>
<td>student decision, recollection, student ability, teacher assistance</td>
</tr>
<tr>
<td>Write the answers</td>
<td>Students learn to use information from the computer to answer the questions</td>
<td>teacher, worksheet, computer, online article</td>
<td>Students use the information they found in the article to answer the question.</td>
<td>student decision, teacher guidance</td>
</tr>
</tbody>
</table>
## Kelly

### Halloween Candy Graphing Activity

<table>
<thead>
<tr>
<th>Step</th>
<th>Goal</th>
<th>Operators</th>
<th>Methods</th>
<th>Selection Rules</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Count Candy</strong></td>
<td>Collect data in a systematic way</td>
<td>Candy, paper, pencil, workspace</td>
<td>Separate candy by category. Count candy in each category.</td>
<td>Categories decided at school.</td>
</tr>
<tr>
<td><strong>Enter Data into excel</strong></td>
<td>Create a data table by typing in labels and amount of candy collected</td>
<td>Computer, data on paper.</td>
<td>Type categories into adjacent cells in the first row, type the amount of candy into second row.</td>
<td>First Row and second row used as shown by the teacher.</td>
</tr>
<tr>
<td><strong>Insert Graph</strong></td>
<td>Create the basic graph for displaying data using Microsoft Excel</td>
<td>Insert Menu Bar, chart types</td>
<td>Highlight the data entered. Click on insert tab and choose the type of chart to create.</td>
<td>Follow Teacher model of how to insert a graph. Choose graph type based on interest.</td>
</tr>
<tr>
<td><strong>Add Labels to Chart</strong></td>
<td>Create a layout for the graph that satisfies teacher requirements of a graph.</td>
<td>Layout Menu Bar in Excel</td>
<td>Select the Layout tab on the top of the screen and choose the layout for the chart that has labels for each axis and a title for the chart. Type in titles for the axes and the graph.</td>
<td>Follow teacher model showing expectations of a graph. Type in labels as shown by the teacher.</td>
</tr>
<tr>
<td><strong>Design the look of the Graph</strong></td>
<td>Learn to manipulate the features of the graph.</td>
<td>Design Menu Bar, Options menu, Color selection.</td>
<td>Select the Design tab on the top of the screen and select the color of the chart. Adjust the look of the chart by widening or thinning the bars of the graph.</td>
<td>Follow teacher model showing the process of selecting colors and adjusting bar thickness. Students choose a color that they like or that they think looks nice for the graph.</td>
</tr>
<tr>
<td><strong>Add Clipart (OPTIONAL)</strong></td>
<td>Learn to insert different features in the chart.</td>
<td>Insert Menu Bar, Clipart options</td>
<td>Students click on the graph and select the insert tab. Select Clipart and choose an image from the list.</td>
<td>Do students want to add clipart? Time allotment. Skill with computer.</td>
</tr>
<tr>
<td><strong>Print</strong></td>
<td>Make a physical version of the graph to turn in to the teacher</td>
<td>File menu, print option</td>
<td>Students select File from the top of the screen and click on print. Students print the picture and get it from the printer to turn in to their teacher.</td>
<td>Follow teacher modelling and instruction. Adjust the spreadsheet to fit onto one page of the printer paper.</td>
</tr>
</tbody>
</table>
### Diane and Sam

**Watershed Presentation Activity**

<table>
<thead>
<tr>
<th>Step</th>
<th>Goal</th>
<th>Operators</th>
<th>Methods</th>
<th>Selection Rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>Create Testable question</td>
<td>Students learn to ask questions that can be answered with data</td>
<td>Teacher, class, student</td>
<td>Students work as a class to determine what their testable question is, and how they will test it.</td>
<td>Teacher guidance, student interest, feasibility</td>
</tr>
<tr>
<td>Determine hypothesis</td>
<td>Students learn to make an educated guess that will be answered by the experiment</td>
<td>teacher, student, class</td>
<td>Students work as a class to make an educated guess for the results of the experiment.</td>
<td>student discussion, student decision, teacher guidance</td>
</tr>
<tr>
<td>Collect samples</td>
<td>Students learn to collect data in a systematic way.</td>
<td>student, data source, teacher, class</td>
<td>Students collect samples to test in class.</td>
<td>class discussion, feasibility, student ability</td>
</tr>
<tr>
<td>Test samples</td>
<td>Students learn to test samples with provided material.</td>
<td>Groups, student, teacher, testing kits</td>
<td>Students work in groups to test the samples using provided water testing kits and instructions</td>
<td>Teacher guidance, lab instructions, sample readings</td>
</tr>
<tr>
<td>Create presentation slides</td>
<td>Students learn to create a powerpoint that shows information and supports a presentation.</td>
<td>Computer, groups, student, teacher, powerpoint</td>
<td>Students work in groups to create different portions of the overall powerpoint presentation.</td>
<td>teacher guidance, expectations, student design</td>
</tr>
<tr>
<td>Create overall presentation</td>
<td>Students learn to collaborate on a presentation</td>
<td>Class, teacher, student, computer, powerpoint, projector</td>
<td>Teacher combines all the different portions and students work to decide on a common design and font for the presentation. Students then proofread the presentation and tell the teacher about changes that need to be made. Changes are made on the projected presentation.</td>
<td>Teacher guidance, student decision, class discussion</td>
</tr>
<tr>
<td>Present project</td>
<td>Students learn to speak clearly and work as a group to deliver a presentation</td>
<td>group, projector, audience</td>
<td>Students present the project in groups to a panel of scientists as parents and teacher watch. Students then must respond to questions asked by the panel of scientists.</td>
<td>teacher guidance, student presentation, scientist questions</td>
</tr>
</tbody>
</table>
### Cathy

**Spanish Country Presentation Activity**

<table>
<thead>
<tr>
<th>Step</th>
<th>Goal</th>
<th>Operators</th>
<th>Methods</th>
<th>Selection Rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research Country</td>
<td>Students learn to use the internet to search for information relevant to a topic</td>
<td>Computer, internet, books, partner</td>
<td>Students search the internet for information relevant to required topics, and learn about interesting facts about the country.</td>
<td>Assigned topics as well as a student chosen topic of interest.</td>
</tr>
<tr>
<td>Record information and citations</td>
<td>Students learn to record relevant information and cite information to avoid plagiarizing and use of reliable sources.</td>
<td>Worksheet (digital or paper), internet, partner, computer</td>
<td>Students write or type website and book citations in a document and record information to use in the creation of the presentation.</td>
<td>Teacher assigned number of citations and topics to cover about the country, student decision</td>
</tr>
<tr>
<td>Create presentation storyboard</td>
<td>Students Learn to design a presentation collaboratively on paper.</td>
<td>Paper, pencil, partner, worksheet</td>
<td>Students use the worksheet to create a plan for the presentation to maximize the time spent on the computers.</td>
<td>Modeled set of slides required that students can add to enhance the design of the presentation. Appropriate images as students see fit.</td>
</tr>
<tr>
<td>Create Powerpoint presentation</td>
<td>Students learn to use powerpoint that supports an effective presentation.</td>
<td>Computer, partner, internet, images</td>
<td>Create powerpoint from the storyboard and information and images found in the research</td>
<td>Teacher guidelines for presentation, students choice of presentation design, images found on country</td>
</tr>
<tr>
<td>Turn in presentation</td>
<td>Students learn to turn in assignments digitally.</td>
<td>computer, class website, partner, teacher</td>
<td>Students add the presentation document to the teachers website.</td>
<td>Follow teacher instructions for turning in an assignment to the website.</td>
</tr>
<tr>
<td>Present Project</td>
<td>Students gain experience presenting a project as the class expert on a subject</td>
<td>Computer, projector, audience, teacher, partner</td>
<td>Students present the project in pairs to the class with the use of the teacher’s computer and the class projector.</td>
<td>Follow presentation, teacher modelling, prior groups</td>
</tr>
</tbody>
</table>
**Earl**

**Laboratory Stations Activity**

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Collect data from lab stations</td>
<td>Students view live samples and see actual examples of concepts they have learned in class.</td>
<td>iPad, Lab stations, microscopes, lab materials</td>
<td>Students walk to lab station and follow posted instructions. They collect data while at the lab station.</td>
<td>posted steps at stations, iPad capabilities, student decision</td>
</tr>
<tr>
<td>Research between lab stations</td>
<td>Students use the internet to search for identities of microorganisms and review information received in class</td>
<td>iPad, internet, pictures taken during lab</td>
<td>Students return to their desks and use the information recorded in the lab to learn more about what they observed.</td>
<td>Lab sheet and questions, required problem solving, student recollection, student data</td>
</tr>
<tr>
<td>Answer Questions</td>
<td>Students answer questions so the teacher can assess student learning</td>
<td>iPad, internet, class notes</td>
<td>Students use the lab observations and the research to answer specific questions provided on the lab sheet.</td>
<td>Lab sheet, information obtained through research</td>
</tr>
<tr>
<td>Draw and identify microscopic material</td>
<td>Students identify what they observed in the lab.</td>
<td>iPad, internet, drawn pictures, pictures taken</td>
<td>Students draw microorganisms and their features and compare these with internet pictures of microorganisms to identify microorganisms</td>
<td>drawings, pictures taken with iPad, features found in drawings and pictures</td>
</tr>
</tbody>
</table>
## Jane

### Terrorist Event Essay and Presentation Activity

<table>
<thead>
<tr>
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<tr>
<td><strong>Research Topic</strong></td>
<td>Learn how to search the internet with different strategies. Learn about a specific event in history</td>
<td>Computer, internet, search engine, topic, teacher</td>
<td>Students work to find sources of information on their topic that give an account of what occurred using advanced search strategies.</td>
<td>Student choice, Teacher guidance, student limitations, information available</td>
</tr>
<tr>
<td><strong>Gather and cite information</strong></td>
<td>Analyze multiple data sources to gather information on an event</td>
<td>computer, multiple sources of information, student, teacher</td>
<td>Students analyze information from multiple websites, remembering that information may be skewed depending on the region of the publication and the original language of the article.</td>
<td>Teacher guidance, website publication data, origin of website, student reasoning</td>
</tr>
<tr>
<td><strong>Determine Cause and Effect</strong></td>
<td>Analyze pre and post data to determine the specific causes and effects of the event</td>
<td>Student, computer, internet, teacher, multiple sources of information</td>
<td>Students view websites of information before and after the event related to the region, people, and terrorist group to determine cause and effect of the terrorist attack.</td>
<td>Historical data, student connections made to the attack, teacher guidance</td>
</tr>
<tr>
<td><strong>Write Essay</strong></td>
<td>Construct a research essay with proper paragraph structure, formatting, and citations</td>
<td>Essay Template, computer, word processing software</td>
<td>Students compile information into a template for writing the essay and construct an essay.</td>
<td>Essay template, gathered information</td>
</tr>
<tr>
<td><strong>Create Presentation</strong></td>
<td>Create a visual to accompany a presentation on a specific event that engages an audience.</td>
<td>computer, Images, internet, student, teacher expectations</td>
<td>Students create a pictorial presentation that follows the spoken presentation and includes all information given in the assignment sheet.</td>
<td>Student design, teacher expectations, available images, rules of appropriateness</td>
</tr>
<tr>
<td><strong>Give Presentation</strong></td>
<td>Present clearly with visual aids to an authentic audience.</td>
<td>projector, computer, student, audience, teacher</td>
<td>Students present their presentation to the class via a projector and Powerpoint presentation software</td>
<td>Student choice, Teacher expectations, information gathered</td>
</tr>
</tbody>
</table>
References


Triona, L. M., & Klahr, D. (2003). Point and click or grab and heft: Comparing the influence of physical and virtual instructional materials on elementary school students’ ability to design experiments. *Cognition and Instruction, 21*(2), 149–173.


