An Expeditionary Learning Approach to Effective Curriculum Mapping

Formalizing the Process by Exploring a User-Centered Framework

By

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Abstract

Monarch Academy is an Expeditionary Learning (EL) institution, which utilizes a non-traditional educational model that combines all subjects into semester-long projects known as expeditions. In order to properly track the progress of students and to ensure the school is meeting its educational goals, including alignment with Common Core, a process called curriculum mapping has been implemented informally; however, the process has not been centralized nor is it easily accessible by staff and administrators. Commercial curriculum mapping software was researched by administrators, but none met the unique requirements of EL. This study explores and defines a curriculum mapping solution that meets Monarch Academy's needs by providing a centralized, accessible, manageable, and user-centered framework.

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Chapter 1: Introduction

> College readiness should be an expectation not only for traditional college-bound high school students, but for all students at the high school level. It is important to ensure that all students are college ready—and especially important to address the substantial inequalities in college readiness between male and female students and among students from various racial and ethnic backgrounds, geographical locales, types of schools, and family income levels. (ACT, 2004)

This statement, taken from an ACT publication, describes the constant challenge within the public school system today to prepare all students for college, regardless of their background, family income level, and other diverse characteristics. In recent years we have seen educational reform legislation, including the No Child Left Behind (NCLB) Act of 2001 and the Common Core Standards Initiative of 2009. While these reforms often look good on paper, schools and districts tend to suffer both from confusion about how to effectively implement such changes and from a lack of funding to do so. Many districts lack cohesion between their schools in terms of what is being taught and at what level. If a child in the fifth grade transfers from one school to another, often there is no direct relationship in their new classroom to what they were previously being taught. Even worse than this is the lack of standardization between classes within the same grade level at the same school, which is often the result of poor communication and collaboration between teachers and staff.

Traditionally, curriculum committees have met periodically to discuss changes, implement solutions, and monitor curriculum over time. These curriculum committees only meet several times a year, however, and change is often slow. Jacobs (2004) criticized the nature of these committees as bureaucratic, viewing the process of curriculum planning more as a necessary paperwork activity, rather than as a catalyst for positive change within the schools or districts involved. Furthermore, the newer challenges of implementing Common Core will need to include the teachers directly affected by the standards. In order to effectively promote change, Jacobs ascertained that involvement at all levels of the school is needed, from teachers in the classroom to school administrators.

In recent years, a process called *curriculum mapping* has spread across the public school system as a preferred method of prioritizing, planning, and communicating curriculum within schools and the districts they are a part of. "Curriculum mapping" was initially coined by Fenwick English in the 1970s; however, it grew massively in popularity towards the end of the 1990s and into the 2000s. This popularity was spurred by low-cost, software-based mapping systems and greater accessibility to desktop computer systems.

Since then, curriculum mapping has paved the way to a more standardized approach to curriculum planning, incorporation of the Common Core, and a better framework to map consistency both vertically (between grade levels) and horizontally (across grade levels). This has proven to be very successful in the traditional public school model, where the subject/lesson/unit hierarchy exists within the curriculum. It can also be adapted to serve non-traditional models where the structure of the curriculum differs from this pattern; however, in these cases, it can pose some additional challenges.

Traditional schools are able to implement existing out-of-the-box software solutions, such as TODCM, Curriculum Mapper, and Atlas Rubicon. Non-traditional schools, which do not follow the out-of-the-box model, have the option of customizing one of the already available products or of building their own solutions. Customization is sometimes the preferred choice, but it can come at a financial cost, and quite often the process of trying to use an already-built solution to solve a unique problem can pose significant challenges. Ideally, it would be better to first define the problem and then build a solution. This option, however, requires programming expertise that is not commonly available within the school; it would require the help of an external consultant, which again brings us back to the issue of financial cost. The purpose of this research project was to investigate the problem of curriculum mapping in the context of a non-traditional school, and to provide a cost-effective solution in the form of a software-based curriculum mapping system that meets the school's unique needs.

In April 2013, a meeting was held with the administration team of Monarch Academy Public Charter School to discuss their current curriculum mapping process. Monarch Academy is an Expeditionary Learning (EL) institution and is a member of a broader base of EL schools. The roots of EL can be found in research about experiential learning. Because of its focus on learning through experiences, the EL curriculum differs from the traditional format of grade-level subjects, units, and assessments. Each semester is built around an *expedition*, which encompasses a number of different subjects. Rather than learning each subject through a series of lessons and units, as in a traditional K-12 environment, an expedition aligns all subjects to a common theme or concept, bringing content and skill standards to students by connecting learning to real-world issues and needs. Learning is demonstrated through projects, fieldwork, service learning, interaction with experts, and a "final product" or project. Assessment takes the form of both summative methods and a formative "final product" at the end of the semester, which aims to demonstrate the "deeper" learning achieved by its students. Not only do expeditions differ greatly from the traditional unit-based curriculum, they also change every year. This poses additional problems for planning and mapping the curriculum, especially when considering Common Core standards. EL requires a system that not only caters to these differences, but also takes advantage of them in a way that a traditional curriculum map would not be able to.

The April 2013 meeting revealed that the administration team had struggled to find an effective curriculum mapping solution that would meet all of their needs. They spent many months researching commercial and open source software, only to find that existing curriculum mapping software was geared towards a traditional school curriculum. In these types of systems, once a map has been built, it remains fairly standardized from year to year. Expeditionary Learning's expedition-based semesters, on the other hand, involve different case studies and subcomponents every semester. While the outcomes each year remain the same, the expeditions themselves vary greatly from year to year. Consequently, the school requires a mapping system that fits into the EL framework, providing a way to publish entirely different expeditions each year, but with the ability to bring forward components of past years. Monarch Academy also relies heavily on an outcome-based approach and has adopted Wiggins and McTighe's Understanding by Design (UbD) framework to guide curriculum development. Therefore, a mapping system would need to allow the school to implement the UbD framework effectively, while also integrating the mapping with Common Core. After finding no out-of-the-box software that would meet these needs, the administration team decided to adopt a less technical approach, using offline spreadsheets, Word documents, and network share drives. This resulted in a labor-intensive process that was not as reliable or collaborative as it could have been.

After the meeting had concluded, it was clear that Monarch required a system built specifically to fit their needs, rather than an attempt to retrofit an existing system to their unique educational model. In the past, mistakes had been made with other third-party software implementations. Applications that could only be accessed from certain computers on location, applications that were difficult to use, and applications that were forced to fit a purpose they had not been designed for were all contributing factors to the ensuing frustration of teachers and staff, ultimately leading to a failure in adoption. In the April meeting, some of these prior issues were discussed. It was agreed that any proposed system must follow a user-centered approach that would meet the needs of the administrators and teachers, and provide a way to enhance, not hinder, their process of curriculum mapping.

This project builds on previous research as well as the unique characteristics and needs of Expeditionary Learning in order to provide an effective solution for EL schools. The research contained within this dissertation has broken new ground in user-centered design principles applied to specific needs within Expeditionary Learning. This study has aimed to answer the following questions:

- What are the unique curriculum standardization needs and requirements of administrators and teachers within an Expeditionary Learning school?
- How can a proposed curriculum mapping solution address the distinctive challenges of Expeditionary Learning while adhering to user-centered design principles?
- How do teachers perceive current curriculum mapping techniques and proposed changes, and what can be done to increase the likelihood of long-term user acceptance?

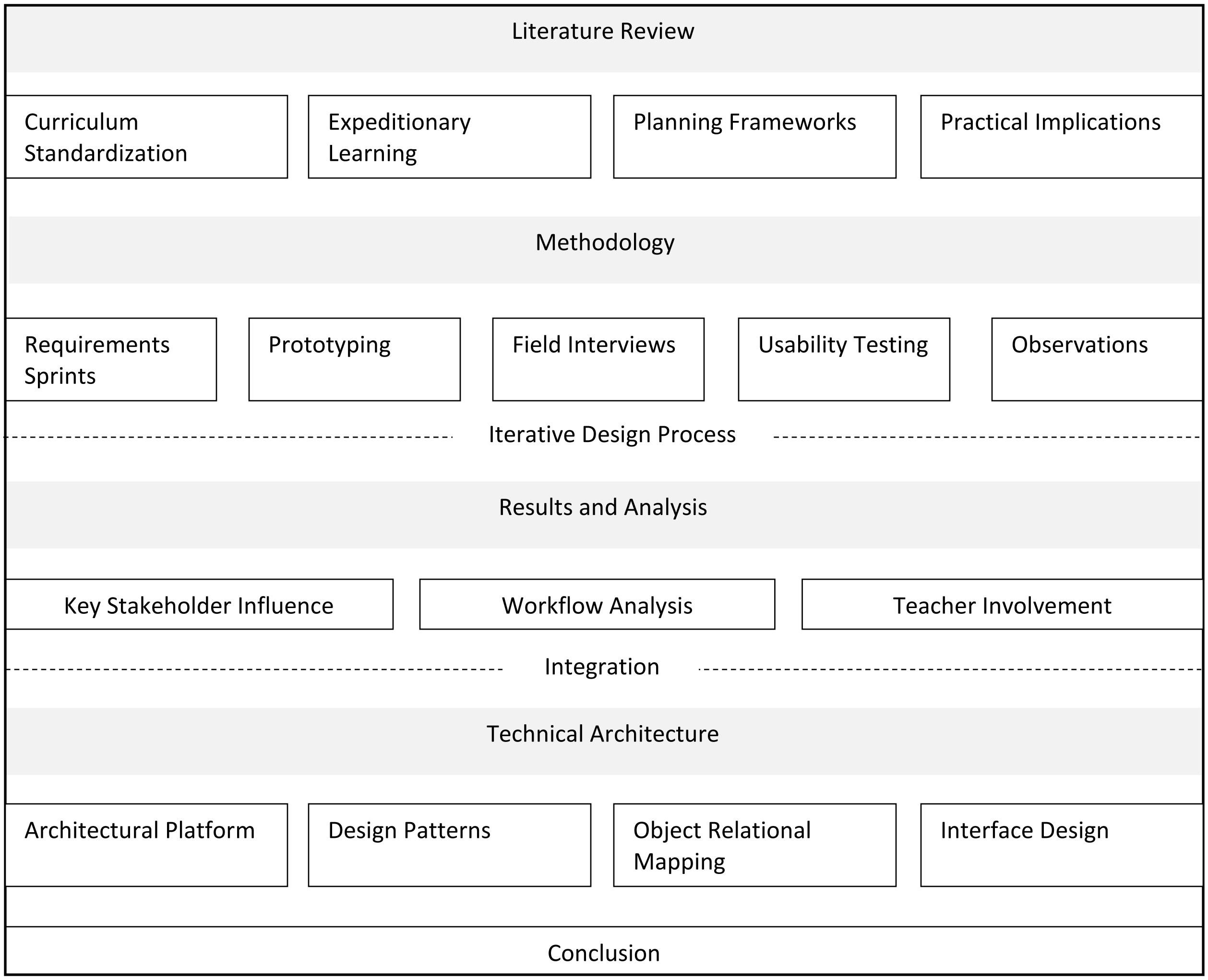


Figure 1: Project Structure

The project outline above (Figure 1) provides a high-level overview of the areas covered in this study. The literature review that follows in the next chapter examines the current body of knowledge regarding curriculum standardization, curriculum mapping, Expeditionary Learning, planning frameworks, and the practical implications of creating software that will be accepted by users. This provided the background research needed to better understand the challenges of curriculum mapping for the EL environment. The information gathered in Chapter 2, coupled with the various research methods detailed in Chapter 3, provided baseline standards for building a proposed solution. The research methods used include requirements sprint meetings, prototypes, usability testing, field surveys, and observations. The results of this research are documented in Chapter 4 and include an analysis of the data collected and overall recommendations for the proposed design. The application was then built upon user-centered research around the requirements of both Monarch Academy and EL. Chapter 5 contains the technical specifications of the alpha build of the software and recommendations for future implementation. Chapter 6 describes the study's limitations, its contributions to the research, and suggestions for further research regarding the application and its applicability to other non-traditional curriculums.

Chapter 2: Literature Review

The purpose of this research study was to design a user-centered curriculum mapping solution for Monarch Academy, built for Expeditionary Learning and compatible with a backwards-design or outcomes-driven planning framework. The overall goal was to present a proposed solution to the school which would be accepted and adopted by administrators and teachers. In order to achieve this goal, it was necessary first to analyze the existing body of knowledge and research in several areas.

At the root of the problem, Monarch did not have any standard way of mapping Common Core to their curriculum. In addition to this, other than the semiannual curriculum meetings, there were no solid mechanisms for curriculum standardization in place. The first section of this literature review focuses on standardization of curriculum, and the second explains what curriculum mapping is and why it is a viable tool for mapping Common Core. The next two sections give a thorough overview of Expeditionary Learning and its role within the education system, and also explain why the unique characteristics of this educational approach, including its ever-changing expeditions, require a different approach from traditional curriculum mapping. Because Monarch Academy incorporates a backwards-design or outcomes-driven approach to building their curriculum at all levels, an overview of planning frameworks, with a heavy emphasis on Wiggins and McTighe's Understanding By Design, has been included. Bringing together these research themes is important in order to understand the practical implications of building and implementing a proposed solution. This is why the final section of the literature review focuses on long-term acceptance of technology, as well as other issues, including security concerns. By reviewing these areas of research, it was possible to analyze the gaps that needed to be filled in order to produce a user-centered solution for Monarch Academy.

Standardization of Curriculum

Within the United States, the Common Core standard has been developed to define academic learning goals for K-12 students. Common Core has effectively encouraged schools to come up with better ways to track their own curriculum in order to ensure they are meeting state standards. Curriculum mapping has provided a toolset to enable schools to do this. Curriculum mapping is a process of documenting the lessons, activities, and assessment methods used within different grade levels and classes in an educational institution. Before looking at curriculum mapping in depth, it is first essential to understand why Common Core has become the driving force behind this movement to develop effective mapping strategies within schools.

The Common Core is a comprehensive set of standards built upon the strongest standards that many states already had in place. It creates a common understanding of what students should know and be able to do in order to be successful in college and the workforce. Common standards ensure that all students receive an equitable, high-quality education. The Common Core was built upon the strengths of current state standards, based in research and evidence. It upholds high expectations, particularly stressing college and workforce readiness. It encourages equality by holding all students across the nation to the same standard of education and expectations, benchmarked against global standards.

Common Core has been voluntarily adopted by 48 states and territories (including the District of Columbia). Because of this adoption, schools are now responsible for ensuring that the Common Core standards are met in their curriculum, which has led to the need for better, more effective curriculum mapping processes. It is therefore important to note that the standards in Common Core are not a curriculum; they are essentially “targets” which students are expected to meet. It is up to individual schools and districts to determine how they will ensure that their students reach these targets. Common Core is the latest in a long line of legislative reforms within the education system of the United States. Table 1 summarizes education reforms from 1787 through 2009 (when the Common Core initiative was launched).

Table 1 - Timeline of Educational Reform Leading to the Common Core

1787	The Constitutional Convention endorses a Constitution that doesn't even have the words "education" or "schools" in it.
1791	The Tenth Amendment to the Constitution puts education in the hands of the states.
1892	The Committee of Ten, formed by the National Education Association, suggests the need for standardization of the high school curriculum.
1900	The Association of American Universities strives to make American universities competitive with their European counterparts.
1917	The U.S. Army introduces standardized testing in an effort to screen recruits based on cognitive abilities.
1926	The first SATs are administered.
1939	Weschler Intelligence Test is administered.
1959	The first ACTs are administered.
1957	The launching of Sputnik fuels the American push toward increasing research and funding in education, particularly in math, science, and foreign languages. The National Defense Education Act does exactly this.
1975	*Newsweek* publishes a cover story entitled "Why Johnny Can't Write," bringing to light the huge gaps in the educational system.
1983	The National Commission on Excellence in Education publishes *A Nation at Risk*, calling for more forward thinking in American schools.
1993	The Massachusetts Education Reform Act mandates statewide standardized curriculum and assessments.
2001	George W. Bush signs into law the No Child Left Behind Act, which mandates high-stakes testing and holds schools accountable for low test scores through penalties for not making yearly progress.
2009	The Common Core Standards Initiative is launched in an effort to unify the nation's educational standards, so as to equitably prepare all students for college and careers in the workforce.

Many strengths and benefits have come out of Common Core. The Common Core standards ensure a more demanding curriculum overall across states, districts, and schools. McPartland and Schneider (1996) confirmed the idea that students learn more if they are offered a more demanding curriculum. More recently, researchers within the Department of Education examined data collected from students enrolled in various high school curriculums; their analysis found that even students who enter high school with test scores in the lowest quartile grow more in college-prep courses than they do in either the vocational or general courses in which they are typically enrolled (Barth, 2004).

The fundamental goal of Common Core is to standardize curriculum in a way that will help prepare students to be “college-ready” upon graduation from high school. More college-ready students means more workforce-ready young adults, which in turn creates a more globally competitive economy for the country. While the U.S. Census Bureau found that the wages earned by White young adults were higher than their Latino or African-American counterparts in most areas, despite degrees earned, there was one subgroup that defied this rule: at the highest literacy level, income inequities between groups were virtually nonexistent, meaning that high literacy rates leveled the playing field across ethnic groups when it came to wage earning (Sum, 1999).

Additionally, Common Core has provided a set of standards that will ultimately increase cohesion between schools and districts. A child beginning a school year in one district and finishing in another will not have an interrupted education. Common Core standards will also allow broad-based sharing of “what works” within and across schools, districts, and states. Thus, efficiency will be increased (Mathis, 2010).

Currently, Common Core has defined standards across the literacy and mathematics subject areas. There are plans in the future to include social studies and the sciences. The literacy component is broken into three sections: K-5, 6-12 English and Language Arts, and 6-12 Literacy in History, Social Studies, Mathematics, Science, and Technical Subjects. Each section is further divided into four strands: Reading, Writing, Listening and Speaking, and Language. The mathematics component is similarly broken down into Domains, Standards, and Clusters.

Domains are large content areas, like "Numbers and Operations"; *Standards* are definitions of what students should know and be able to do; and *Clusters* are groupings of more specific standards that break down the skills to be addressed. The math component includes grade-level overviews that help define the overarching mathematical themes of that grade level and focal points that pinpoint critical areas for instruction.

Common Core has not been without criticism. There is significant worry that unacceptable rates of failure by students may accompany higher curriculum standards. This is particularly relevant because Common Core lacks interventions for students who may be performing below grade level. Students who need extra support as English language learners or who have special needs may be most vulnerable. A more rigorous curriculum also means that schools will need enough teachers who are knowledgeable in strategies for helping students to master high-level content as well as being knowledgeable in their subject areas. In addition to this, national and statewide assessments will need to be realigned to conform to the standards, including "aligned assessments for both individual diagnostic use in the classroom and for school accountability" (Barth, 2004). The fear remains that enacting a common set of standards—and thus a common assessment tool—would reduce teaching to only a narrow range of testable information, and would not produce the knowledge, flexibility, and creativity needed for a new and uncertain age (Noddings, 2010). Another significant concern many schools and districts have is that implementing a nationwide standards system means adopting a whole new curriculum, which requires throwing out and replacing all of the current curriculum documents, resources, materials, etc. This may result in a huge financial burden for schools that are already struggling to find funding.

The Unites States has a long way to go before education is fully effective for all American students. Even with the criticisms listed above, the Common Core is a significant step in getting to that end. It sets the bar high for student and teacher expectations and serves as a comprehensive collection of what the country deems it necessary for students to study. Most importantly, it unifies a nation of learners and teachers in the fight towards a level of competence and literacy that will make the next generation of youth competitive in the global economy.

The larger challenge of effectively meeting these standards has been addressed in different schools and districts by carefully planning their curriculum, using tools and frameworks to effectively link educational activities to Common Core. Curriculum mapping is one such tool. It has provided a tried and proven mechanism for developing a more standard educational experience across grade levels as well as between schools. In recent years, thanks in part to the work of Dr. Heidi Hayes Jacobs, it has become vastly popular, particularly as computer-based mapping has become both cost-effective and accessible.

Curriculum Mapping

In order to understand the significance of curriculum mapping, it is necessary to examine its history and impact on the public school system within the United States. Fenwick English, a well-known curriculum leader and theoretician, pioneered curriculum mapping in the late 1970s. The first curriculum maps were developed to reveal which topics and skills were being taught and for what period of time. Evaluators used surveys and interviews in order to gather information from teachers about how long they would spend on certain topics and what was being covered. English described the importance of curriculum mapping in terms of revealing to staff and administration “what is actually being taught, how long it is being taught, and the match between what is being taught and the district’s testing program” (1980). The end result of the map provided the curriculum developer with data on how much time teachers spent on topics and the order in which those topics were covered within the classroom environment. More importantly, the process revealed variations in practice from teacher to teacher, providing the administration with valuable information on where curriculum changes and improvements might be needed.

This early form of curriculum mapping, while effective, was very time consuming, as it required large amounts of data to be collected and disseminated. Advances in computer technology in the late 1990s brought about massive improvements in the process of curriculum mapping. Around this time, research on the subject was broadened and popularized by the work of Dr. Heidi Hayes Jacobs, who took curriculum mapping to the next level through the use of technology and strategies that increased teacher involvement throughout the mapping process. Jacobs authored the well-known publication on the topic, *Mapping the Big Picture*, which became the foundation for many educational institutions' curriculum mapping initiatives. Jacobs enhanced the earlier work with a number of new features, including teacher-driven curriculum mapping, horizontal and vertical alignments, cyclical reviews, and professional curricular dialog (Udelhofen, 2005). According to Jacobs, "curriculum maps have the potential to become the hub for making decisions about teaching and learning," especially through the use of the Internet, where resources can be accessed from anywhere (2004).

There have been numerous cases where curriculum mapping has been effectively implemented within different school systems, in terms of both the process itself and the toolset used. Successfully implementing curriculum maps involves careful planning along with buy-in and involvement from teachers and administrators throughout the school. In the second chapter of her book *Getting Results With Curriculum Mapping* (2004), Jacobs discusses School District

Five. This district used Jacobs' approach in implementing curriculum mapping in all of its schools, which proved to be a success.

As described in the book, School District Five is composed of 19 schools that serve approximately 16,000 students, from child development through adult education. In the mid-1990s, the district saw demographic shifts that impacted all of its schools. The school populations became more diverse, and this resulted in a set of new challenges that the district had not been prepared for. The shift was dramatic; within a short period of time, it resulted in one school moving from 15 percent of its student population on free and reduced-price lunches to 50 percent.

During the period before the demographic shift, the district had typically performed well in terms of test scores, student performance, and graduation rates. The new demographic shift, however, presented challenges with students who had different needs from the previous population. Up until this time, there had been a lack of horizontal consistency among grade levels between the schools in the district. What a student learned in third grade in one school might be completely different from what was being taught in third grade at another school. Much of the learning depended on what each teacher emphasized within the grade, which was only loosely based on standards. When more strict standards were enforced, many teachers resisted using them, as they felt that the new student population was not capable of the work.

District leaders turned to curriculum mapping to help them better meet the needs of the changing student population and to improve consistency between grades and schools. The approach they adopted ultimately led to a stronger, more cohesive community. In her book, Jacobs describes *support beams* (stakeholder involvement) and leadership roles within upper levels of the district being pivotal to the process. It was necessary to involve these key stakeholders and to get their buy-in at the beginning of the project to ensure success. Two principals selected over sixty teachers—representing various grades, subjects, and schools—to be recruited to work in a graduate cohort to study the feasibility of implementing curriculum mapping. Much of the work focused on Jacobs' research in curriculum mapping, and the graduates became the chief architects of a community-building initiative that led to the involvement of all schools in the district. The architects carefully designed the process, identified the tools needed, and pledged a three-year commitment to the building process, using Jacobs' framework for more than 2,000 teachers. Eventually, content areas were mapped and processes were put in place for sustaining the process throughout the rest of the district. The curriculum maps became the hub for highlighting continual instructional changes and refinements. As Jacobs noted, "Mapping provided a process for collegial dialogue on alignment of content, skills, assessments and activities across 19 schools, with its ultimate goal of improving student achievement" (2004).

As with any toolset or process, the question must be asked: is it worth implementing in a school or district? Other studies have measured both the effectiveness of curriculum mapping and the perceptions of teachers and administrators regarding its viability. One such study was carried out by Lucas (2005); his doctoral study measured teachers' perception of the efficacy of curriculum mapping as a tool for planning and alignment. In that study, 573 teachers from 19 schools in a district in South Carolina participated in surveys and focus group sessions, which were used to determine teacher perceptions of curriculum mapping. Descriptive statistical data was gathered regarding overall teacher perceptions of curriculum mapping as a planning tool. The results demonstrated that the majority of teachers saw curriculum mapping as an effective tool for curriculum alignment, long-range planning, and to a lesser degree, as a supportive tool for short-range planning.

Another study took place in Ohio, where research was carried out to identify the most effective practices resulting in substantial student achievement in 50 of the state's school districts. The research included online data collection, telephone interviews, and site visits with over 400 teachers, superintendents, and administrators. It was found that curriculum alignment (defined as curriculum mapping with subsequent change in instructional practice) was the "single greatest factor in achieving improved test scores" (Kercheval, 2001). Beyond test scores, curriculum mapping has also been found to increase overall shared responsibility and collaboration among those participating in the process. In a qualitative study by Uchiyama and Radin (2008), results showed that the curriculum mapping process, in addition to aligning and articulating the curriculum, fostered collaboration and a sense of ownership of those participating.

Within the traditional public school system, curriculum mapping has become a popular method for ensuring a more consistent educational experience across grades and across schools in the district. It is becoming a vital tool for many schools to ensure their curriculum meets Common Core standards. There are, however, many types of non-traditional educational institutions across the country, with vastly different needs from the typical public school. Charter schools are an alternative within the United States; they receive public funding from the state, but they may function differently and are often more similar to private institutions. There are a number of non-traditional approaches to education used by private and charter schools, including the Montessori approach, which emphasizes independence and freedom within limits of a child's education. Expeditionary Learning (EL) is a non-traditional type of charter school, where a different method of education, following the experiential model of learning, has been adopted. The standard curriculum mapping used in public schools is not compatible with EL schools because their curriculum does not follow the typical curriculum structure of units, lessons, and coursework. In EL, expeditions encompassing many subjects replace standard semesters, and these expeditions vary greatly from year to year, posing additional challenges for effective curriculum mapping. In order to understand these challenges better, it is first necessary to look at Expeditionary Learning in more depth.

Expeditionary Learning

Expeditionary Learning (EL) is a non-profit, chartered entity of Outward Bound, which promotes and supports the efforts of chartered EL schools across the United States. *Expeditionary Learning* refers to both the organization that supports it and the type of instruction it embodies. Expeditionary Learning was born out of a collaboration between Outward Bound, USA and the Harvard Graduate School of Education. The Harvard Outward Bound project, established in 1987, sought to increase the profile of experiential education at Harvard's School of Education, while also bringing increased academic rigor to Outward Bound's work in schools. The proposal to create EL was a marriage of the philosophies of Kurt Hahn, founder of Outward Bound, and the best of the Harvard Graduate School of Education's theoretical and practical approach to teaching and learning (Expeditionary Learning, 2012).

Expeditionary Learning is grounded in the theory of experiential learning, which in itself was drawn from the foundational theory of experience put forth by Dewey (1938) and Lewin (1951). *Experiential learning* is defined by Kolb (1984) as the process by which knowledge is created through the transformation of experience. It emphasizes the central role that experience plays in the learning process and regards learning as a holistic process, "grasping the experience" and "transforming the experience." Expeditionary Learning has built on experiential learning by integrating parts of this instructional strategy into a model that provides learning opportunities through expeditions—interdisciplinary investigations of real-world issues—which typically take place several times throughout the school year in EL schools.

The Expeditionary Learning model consists of 38 core practices in the form of a framework for learning success. Each of the core practices addresses what EL describes as the *five key dimensions of life in school* that shape student achievement. These five key dimensions consist of curriculum standards, instructional techniques, assessments and targets, culture and character, and leadership. These core practices are recipes of tried and proven best practices that have been documented in EL schools across the United States. They are provided as a guide, not requirements, and they provide flexibility for teachers to implement parts of them in their own unique way, depending on the needs of their classrooms (Expeditionary Learning, 2012).

Expeditionary Learning periodically publishes information on their website about how well their supported EL schools perform in terms of academic achievement. They assert that, on average, EL schools have consistently outperformed traditional K-12 schools, regardless of demographic differences and income levels (2013). EL has also sponsored several studies over the years to determine the effect this type of instruction has on participating charter schools. Different research methods were employed, including comparative studies against standard test scores within both EL and non-EL participating schools. Regression analyses were conducted to control for gender, ethnicity, and special education status. Several studies at Rochester, New York, published on EL's website, demonstrated that EL schools in this area performed better than their traditional school counterparts (Expeditionary Learning, 2013).

While the results of these studies were overwhelmingly positive, results also showed that, in certain situations, EL resulted in a negative effect on depth and understanding, especially in connection with STEM disciplines and general mathematical concepts. It was concluded that the EL approach provides less breadth and repeated skill practice than may be needed in these subject areas, which are assessed on state exams. This was particularly evident in the Rochester study, which demonstrated that test scores for mathematics showed a significant advantage to non-EL schools in middle school grades (UMass Donahue Institute, 2011). Studies are ongoing, and EL continues to release new findings as it engages in this type of research. The results concerning STEM disciplines, however, reflect on the way certain EL schools have treated these subjects within their curriculum. For example, Monarch Academy has implemented expeditions throughout most of its curriculum, except for certain math and science disciplines, which research has shown, in some situations, to be better taught using more a more traditional approach to instruction.

Other research has been published on the learning benefits of EL. A longitudinal study conducted by Mathematica Policy Research was published in *Education Week* in 2013. The research took place within five EL middle schools in Washington, D.C., and New York City, which were compared with traditional district schools with similar demographics. The results of the study demonstrated improvement gains in both mathematics and reading. The results also demonstrated additional improvements for students that remained in the EL program for all three years of middle school. In fact, those students who stayed in the program for the entire three-year period gained seven months more learning in reading and ten months more in math than their counterparts in the district schools (Sparks, 2013).

An overview of the European Higgins Lake Expedition Inside culture program was published by Bell, Daniels, and Lawless (2011). Their publication claims that past participants of this program have shown that Expeditionary Learning is successful and meaningful. Beyond the test scores, past students took the skills they had acquired into leadership roles and spoke positively of their experiences to current students. Measurable success was evaluated through students' increased interest each year as well as post-high school outcomes, including college admission numbers.

Curriculum Mapping for EL

Although the curriculum mapping process presents a number of challenges for EL schools, it is nonetheless pivotal to the Expeditionary Learning approach to education. The concept is not only explicitly referenced throughout the core practices of the EL model, but it also complements the vision EL brings to schools and districts. Without the tools and processes curriculum mapping provides, many of the documented EL practices would be greatly hindered or, in some instances, not possible to effectively manage. Curriculum maps are addressed within the EL core practices and form a solid toolset for the framework in linking expeditions and curriculum directly to Common Core standards. They are fundamental tools within the curriculum, assessment, and leadership key dimensions of Expeditionary Learning. Curriculum mapping is primarily responsible for aligning standards, providing for skill and concept maps, and developing more detailed instructional content maps for teachers. Curriculum maps are instrumental in designing learning expeditions and in identifying key standards aligned with global skills and knowledge, ensuring content is reflected adequately. In terms of assessment, teachers use curriculum maps as a tool to enable them to craft quality learning targets with common characteristics. Expeditionary Learning (2012) describes these characteristics as being derived from national or state standards and school or district documents, including curriculum maps.

Many of Jacobs' recommendations from *Getting Results with Curriculum Mapping* can be applied directly to the EL model for mapping core standards to expeditions (2004). There are, however, areas within EL that are fundamentally different from most other school systems. These differences include the general terminology and nature of expeditions, along with their dynamic characteristics, the integration of fieldwork and experiences as a significant part of the curriculum, the different types of assessment methods, and the distinctive potential for gaps in an EL curriculum. Each of these differences presents a unique set of challenges for EL schools.

In a typical school, once the curriculum is mapped, there are few significant changes in the types of units and lessons recorded. In an EL school, semesters are made up of expeditions instead of a predefined set of units and lessons. These expeditions are continually evolving and are updated every school year, so while the standards remain consistent, the type of instruction can vary greatly, which often requires much coordination across grade levels between teachers and the administration team. The nature of these changes requires a more fluid or dynamic approach to mapping the curriculum, allowing access to previous expeditions as well as the ability to easily update and import resources for the current school year. Jacobs' model and other curriculum mapping approaches address the need for supplemental instructional resources that would be available to similar units; however, because of the ever-changing nature of expeditions, mapping these resources may present additional challenges.

The unique nature of expeditions requires careful thought and planning when mapping the curriculum. Widely varying elements of instruction—such as case studies, fieldwork, expert visitors, web-based activities, objects, and experiences—are used in place of more traditional textbook materials. Quite often an expedition, which may cover several different disciplines, will not have a defined textbook, but will instead use a number of these different instructional resources throughout the semester.

Assessments within EL are also different from those in traditional education models. A "final product" comprises the deliverables that students create at the end of an expedition. Examples of past final products at Monarch Academy include student-created books, classroom museums (constructed by students), public service announcements, and theatrical performances. This type of assessment encompasses all the skills within the expedition that the student has had to learn throughout the semester. Scoring of EL assessments also differs from traditional models; assessments rarely have one right answer, and the approach is more interested in the thought processes that enabled the student to reach an answer. This is similar to Wiggins and McTighe's Understanding by Design educational model, which emphasizes critical thinking and creativity in assessment methods (2005).

The teaching of broad expeditions throughout several different grade levels carries the risk of skills being missed. Without a comprehensive curriculum mapping process in place that supports EL, skills could be overlooked or become redundant by being repeated at different grade levels. The dynamic, changing nature of expeditions, along with their multi-discipline approach, increases the chances of gaps in the curriculum. State standards typically include a natural overlap or stair-stepping progression of difficulty. This is problematic to establish in EL, which means that a comprehensive curriculum mapping process becomes even more important in order to support this tiered approach. Because EL doesn't conform to these tiers as readily as other educational models, an effective EL curriculum mapping process also needs to allow for out-of-the-box thinking.

Expeditionary Learning is a modern approach to providing experiential learning opportunities within the curriculum. It fosters creative learning and promotes critical thinking through semester-long expeditions, which replace the traditional unit-based instruction. This approach presents its own unique challenges in mapping the curriculum. In order for EL schools to effectively manage their curriculums, while also meeting state standards, a tailored approach to curriculum mapping based on the existing research must be used in place of other standard solutions aimed at the traditional public school. In addition to this, any solution proposed must be compatible with the school's educational philosophy, instructional planning framework, and overarching goals.

Planning Frameworks

Monarch Academy actively leans on an outcomes-based or backwards design of curriculum, in which the outputs or goals are crafted first, and the assessment and instructional methods to meet those goals are developed later. Monarch has used the Understanding by Design (UbD) framework, developed by Wiggins and McTighe in the late 1990s, to guide their development of expeditions for some time. In order to better understand the already unique needs for curriculum mapping within Monarch's EL environment, an examination of this and other similar planning frameworks is important.

The idea behind UbD is that understanding should not happen by accident: it should be designed or planned into the curriculum. The framework itself advocates for keeping long-term goals (student understanding) within view, while using the right blend of content, instruction, and interaction to engage learners. Long-term educational goals should be a part of the short-term, day-to-day lesson planning for the classroom (Wiggins & McTighe, 2005).

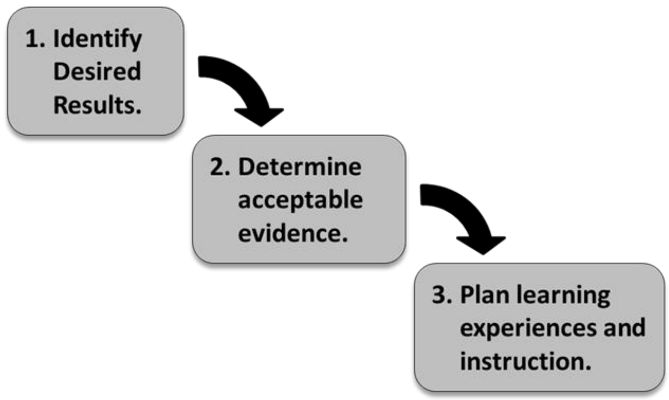
According to Wiggins and McTighe (2005), there are certain design tools that can help teachers be more likely to reach their educational goals, regardless of their student population and other constraints. These tools flow from a basic design strategy called *backwards design*. The authors make it very clear that backwards design refers to an approach to goals, not content. The end result should not be to ensure that students have covered all assigned content within the classroom, but instead to provide students with content and learning experiences they can use and apply to reach learning goals.

Backwards design is an educational methodology that promotes *results*-focused design in place of *content*-focused design. Content-focused design can be described as a process where a particular topic may be chosen as the basis of a lesson. Wiggins and McTighe (2005) used an example to describe this concept. Imagine that a teacher bases a lesson on the topic of racial prejudice. A resource is then chosen—*To Kill a Mockingbird*—and specific instructional methods are based on this resource and topic. These methods could include, for example, a Socratic seminar to discuss the book with cooperative groups to analyze stereotypical images in films and on television. The overall hope is to thereby cause learning and at the same time meet certain Common Core or state requirements for English/Language Arts. Assessment is then baked into this process in the form of a few essay questions for assessing the student's understanding of the book.

This approach is common within the school system, and some may question what could be wrong with planning this way. In order to better understand the root problem, we need to take a step back and ask ourselves why we are asking the student to read this particular novel to begin with. What is it we are expecting the student to understand and to be able to apply in relation to the subject of racial prejudice? Does the student see the purpose in this resource, and does it tie into the overall learning goals beyond the book? In the example situation, if the goals were met, it wouldn't have been by design, but by chance. The fact that the overall goal was vague to begin with—in terms of specific understandings the students were to acquire—causes further problems. Wiggins and McTighe (2005) label this as an approach more "by hope" than "by design." Simply "throwing some content at the wall and hoping it will stick" may ultimately lead to failure.

Another set of problems is common throughout K-12 education. These include activity-oriented design and coverage—also known as the twin sins of design. *Activity-oriented design* refers to the flawed approach of designing learning experiences by crafting engaging activities without considering the overall educational goals. Wiggins and McTighe (2005) refer to this type of design as "hands-on without being minds-on." *Coverage* refers to the misguided approach of assigning complete textbooks or entire sets of lecture material in an effort to cover all the factual material within a specified period of time. This is common in K-12 schools, but it is also particularly prevalent within higher education institutions.

Content-driven design and the twin sins should be avoided; instead, *results-driven design* should be promoted within the classroom. Results-driven design uses the backwards-design methodology, which first identifies the desired results of learning and then determines acceptable evidence (assessment). Finally, after both of these have been determined, the learning experiences are planned out, as shown in Figure 2 and explained in the following paragraphs.



(Wiggins & McTighe, 2005)

Figure 1 - Backwards Design

<u>1. Identify Desired Results</u>

The first stage of backwards design should involve reviewing the overall state Common Core requirements and determining what it is that the student should know, understand, and be able to do in the end. During this stage of design, it should be decided what concepts are important and what enduring understandings are desired from the student. The main constraint during this stage is that teachers typically have more content (in terms of desired concepts) than can be reasonably covered in a specific amount of time. Therefore clarity of prioritization is needed and careful choices must be made.

<u>2. Determine Acceptable Evidence</u>

Determining acceptable evidence ensures that we know if the student has achieved the desired results. The process of determining acceptable evidence encourages the curriculum planner and teacher to think first like an assessor before moving forward and designing specific units and lessons. This ensures that careful thought is given at the beginning about how it will be determined whether students have attained the desired knowledge (Wiggins & McTighe, 2005). During this phase of backwards design, the following questions must be considered. How will we know students have achieved the desired results? What will we accept as evidence of student understanding and proficiency? In the end, students with full understanding should be able to demonstrate what Wiggins and McTighe (2005) refer to as the six facets of understanding:

1. **Explain** concepts in their own words.
2. **Interpret** by making sense of data, text, and experiences.
3. **Apply** by effectively using and adapting what they know in new and complex contexts.
4. Demonstrate **perspective** by seeing the big picture and recognizing different points of view.
5. Display **empathy** by perceiving sensitivity and walking in someone else's shoes.
6. Have **self-knowledge** by showing mega-cognitive awareness, using productive habits of mind, and reflecting on the meaning of learning and experience.

Not all six facets are typically used together in every assessment; however, they provide a guide for measurement when considering acceptable evidence.

3. Plan Learning Experiences

After the desired results have been identified and acceptable evidence and assessments have been determined, the process of planning the individual learning experiences can begin. This is counter to many traditional methods of developing lessons and curriculum within education; however, it is essential in order to ensure that results-driven learning happens within the classroom. At this stage, several things need to be addressed. First of all, the teacher or curriculum designer must consider what enabling knowledge and skills the students will need in order to perform effectively and achieve the desired results. Second, the activities that will equip students with the needed knowledge and skills must be determined; in other words, what will need to be taught and coached? Finally, the materials and resources that are best suited to accomplish these goals need to be identified.

Wiggins and McTighe built the Understanding by Design framework with the help of previous research in the field of cognitive psychology. A readable synthesis of cognitive psychology and its impact on education was published in the National Research Council book *How People Learn: Brain, Mind, Experience and School* (2004). This publication summarized the previous 30 years of research in learning and cognition. It offers new conceptions of the learning process and explains how skill and understanding in key subjects are most effectively acquired. Key findings from this publication have been summarized in Table 2.

Table 2 - Key Findings Relevant to UbD

Views on effective learning have shifted from a focus on the benefits of diligent drill and practice to a focus on students' understanding and application of knowledge.
Learning must be guided by generalized principles in order to be widely applicable. Knowledge learned at the level of rote memory rarely transfers; transfer most likely occurs when the learner knows and understands underlying concepts and principles that can be applied to problems in new contexts.
Experts first seek to develop an understanding of problems, and this often involves thinking in terms of core concepts or big ideas. Novices' knowledge is much less likely to be organized around big ideas.
Curricula that emphasize breadth of knowledge may prevent effective organization of knowledge because there is not enough time to learn anything in depth.
Feedback is fundamental to learning, but feedback opportunities are often scarce in classrooms. What is needed are formative assessments, which provide students with opportunities to revise and improve the quality of their thinking and understanding.
Many assessments measure only propositional (factual) knowledge and never ask whether students know when, where, and why to use that knowledge.
Expert teachers know the structure of their disciplines, and this provides them with cognitive roadmaps that guide the assignments they give students.

(McTighe, J., & Seif, E., 2003)

There is also some overlap between UbD and the theories of Dr. Malcolm Knowles. While Knowles was more concerned in andragogy (adult learning theory), much of his research is also relevant to younger students. Knowles recommends several principles that should be applied to the design of learning experiences. In his first principle, Knowles demonstrates that students have a need to understand why specific things are being taught. Going back to the first phase of backwards design, this principle aligns closely with identifying the desired results by determining what students should know and why they should know it. In another principle, Knowles asserts that students should be focused on problem-centered rather than content-oriented instructions. Here we can see a direct alignment with the UbD framework that identifies one of the twin sins of design—coverage-based education—that should be avoided. Orienting lessons towards content coverage is a misguided approach. Knowles also argues that adults are self-directed and want to discover things for themselves. This is supportive of younger learners, too, within both UbD and Expeditionary Learning (Knowles, Holton, & Swanson, 2005).

Understanding by Design promotes deeper learning within the classroom. Deep vs. surface learning is an area of research that has been discussed frequently over the years. UbD fosters an environment that influences a deeper learning approach. Surface learners tend to fall into the category of students who focus on the importance of "minimum requirements." They are interested only in passing the next test or reaching the "needed" grade in order to get through their course of study. They have little or no interest in creating and adding their own knowledge to theories or subjects which they are learning. "Deep learning involves the critical analysis of new ideas, linking them to already known concepts and principles, and leads to understanding and long-term retention of concepts so that they can be used for problem solving in unfamiliar contexts" (The Higher Education Academy, 2007). Deep learning can only be achieved if the student has an understanding of why they are studying the material presented in their classroom. This is addressed in the backwards-design approach by first identifying the desired results of the learning experience and then making students aware of this.

Wiggins and McTighe's first publication on Understanding by Design (2005) provides an effective model for developing the curriculum using the backwards-design approach. Not only does it provide templates, the book format begins with a high-level view of the curriculum and works through to a more detailed structure. Chapter 12 of the book focuses on what Wiggins and McTighe describe as the "big picture" of using UbD as a curriculum framework. Earlier chapters include detailed information on developing and crafting understanding at the unit level. The curriculum framework examines the school district's overall goals for learning and aligns these with content standards. This framework is directly compatible with the curriculum mapping work of Jacobs. In her book *Curriculum 21*, she focuses on the selection and organization of content around central concepts ("big ideas") supported by selected facts and information (2010).

Wiggins and McTighe published *Understanding by Design Framework* in 2012, a number of years after their initial UbD book. The goal of this new publication was to provide a model that teachers and school leaders could use to design high-quality UbD education. While the first book provided templates and an overview of what UbD is, Wiggins and McTighe felt it did not go far enough in providing a guide to actually planning for understanding and designing quality essential assessment questions. This publication also came with more in-depth templates for developing a robust UbD curriculum.

Additional research has been done on this framework. Shumway & Berrett (2004) published the results of a modified approach to backwards design carried out at Brigham Young University. The purpose was to improve their students' knowledge of the new Standards for Technology Literacy (STL) and to help them implement the standards within local schools. The students in the study were in the teacher education program at the university, and a strategy was devised to educate them about the standards, while at the same time putting those standards into practice at schools where the students participated in teacher training.

Several problems were identified early on in the planning stage. The majority of teachers within the local schools had a copy of the standards and were supportive of them; however, they needed support for implementing them within the classroom. Much of the help needed was to ensure that curriculum units designed for their classes were standards-based and not merely standards-reflective. It was determined that teacher education students at the university needed to have earlier and more frequent teaching and curriculum development experiences in the public school. Students needed to become intimately familiar with the need for these standards and learn how to develop curriculum based on them. The university needed to coordinate efforts and strengthen the partnership between the schools and local classroom technology teachers. All of this led to the development of an initiative using a modified version of backwards design to guide the process, as shown in Table 3.

Table 3 - Modified Backwards Design

Develop Desired Results
Determine Acceptable Evidence (general)
Plan Learning Experiences
Enrichment
Determine Acceptable Evidence (specific)
Evaluation of Curriculum and Continual Refinement

(Shumway & Berrett, 2004)

A modified version of backwards design was used as a result of challenges the students ran into while trying to implement the backwards-design model. The students expressed frustration when trying to determine assessment procedures when no unit or lesson plans had yet been developed. In order to overcome this challenge, the first modification was implemented in the form of determining acceptable evidence at a more general level (e.g. portfolios, projects, etc.) in order to provide specifics later on, after learning experiences had been planned. Another phase called “enrichment” was introduced, which allowed for more collaboration and formative evaluation of the work carried out between the university students and the supervising teacher. Once the unit plan, lesson plans, assessments, and other materials had been developed, the students submitted them to the cooperating teacher for feedback. With the cooperating teacher’s supervision, teams of students then co-taught a short lesson related to the current sixth-grade unit based on the Standards for Technology Literacy (STL). In later years, students would return to teach an entire curriculum unit with local high school teachers. The last phase of the modified backwards-design model involved evaluation of the curriculum along with continual refinement. The modified approach served both Brigham Young University and the local district well for their unique purpose, which required collaboration between two different educational populations.

Backwards design has become a very popular model for designing and implementing curriculum throughout many schools and districts. There are, however, other curriculum models that have gained popularity over the years and which should also be considered when devising any type of curriculum strategy. ADDIE stands for Analysis, Design, Development, Implementation, and Evaluation, which describe the various steps of the model. The ADDIE model provides designers with the necessary structure for designing any curriculum (Hodell, 2006). ADDIE has been revised and modified many times over the years and still remains a popular framework for designing instruction.

The ADDIE model is very similar to backwards design in the sense that its analysis phase is similar to the backwards design phase of identifying desired results of learning. Much of the initial planning for the rest of the design process takes place here. Analysis, in this model, specifies measurable terms and the overall desired level of performance in order to define the overall learning experience, just as in the backwards-design model. ADDIE ensures that a rigorous analysis is carried out, followed by design, development, and implementation of instruction that yields measurable results. The entire process is cyclical; the evaluation phase requires revisiting and improving on design and development activities to ensure that the finished lessons or units meet the goals of the institution. However, while much of ADDIE is similar to backwards design, it lacks certain elements of UbD, including self-evaluation techniques, such as student reflections that involve rethinking and revisiting concepts. UbD is also more closely aligned with K-12 school environment, while ADDIE is commonly used in higher education.

The ASSURE model was developed by Heinrich and Molenda in 1999. It is a well-known instructional design guide using a constructivist perspective, which integrates multimedia and technology to enhance the learning environment (Faryadi, 2007). ASSURE is another curriculum model that uses the letters in its name to represent the various processes involved. “Analyze the learner” is the first phase, where the model encourages the designer to gain an understanding of the students and their needs. “State objectives” is the second phase, which becomes the overall focus of the lessons to follow. “Select media and materials” comes next, to ensure the correct resources are chosen for the type of instruction being designed. This is followed by “Utilize media and materials.” “Require learner performance” is the next phase, which requires the formation of strategies to encourage student participation in the unit or lesson.

"Evaluation and revision" are both covered in the last phase, which refers to evaluation of both teaching and student achievement.

The ASSURE model bears some similarities to the ADDIE model and the backwards-design approach. One issue with the model, however, is that evaluation is left to the end. While it is helpful to know what worked and what didn't, at this stage of the design process it may be too late to intervene for student success. Another point to note with ASSURE is its heavier reliance on technology resources, something the other models do not explicitly mandate. Baran (2010) discusses some of the challenges faced during an ASSURE study in which the particular technology used (Interactive White Boards) had a limited amount of software available for teachers. In this situation, difficulties arose during the 'Select media and materials' phase.

There are a number of other approaches to curriculum development and instructional design that fall outside the scope of this study, such as the 5E Instructional Design Model, the Dynamic Instructional Design Model, and Gagne's Model. But one other method or approach to designing curriculum is important to address, which can be used in combination with the models covered in this paper. This method is called the *bottom-up* or bottom-driven approach to designing and implementing curriculum changes within the school.

Traditionally, a top-down approach to curriculum design has been more common, where initiatives come from the top (school administrators) and are given to the teachers to implement. In recent years, bottom-up strategies, led by teachers, have become more common in combination with frameworks, such as UbD, that encourage teacher involvement in the design of units and lessons. McCarthy (2009) discusses the benefits of this approach and asserts that the bottom-up approach helps to promote changes at the grass-roots level, which in turn has led to more consideration of the needs of learners. McCarthy's study also demonstrates that bottom-up methods help ensure the success of curriculum reform because of buy-in by teachers who are aware of their power as change agents. A similar strategy of bottom-up curriculum design was implemented during a study by Blonder, Kipnis, Mamlok-Naaman, and Hofstein (2008). In this study, teachers were involved in redesigning curriculum, which ultimately led to increased teacher ownership and better alignment with the entire curriculum redesign initiative. While there needs to be a balance between direction from the top and grass-roots involvement, backwards design promotes teacher collaboration, which ensures that appropriate lessons are developed to meet the overall goals of the school, the district, and the Common Core requirements.

Monarch Academy's choice to implement UbD in their curriculum planning makes sense in light of the way UbD complements the Expeditionary Learning (EL) approach to education. Both promote deeper understanding through learning experiences, critical thinking, and going beyond basic and surface-based learning patterns. Students should be able to take away a thorough understanding of the "big ideas" instilled in them through the process of an effectively designed curriculum. These "big ideas" should contain knowledge and experiences that will stay with a student far beyond high school graduation.

UbD can be applied with a curriculum mapping toolset to effectively record, manage, and maintain a standardized curriculum. The existing curriculum mapping framework developed by Jacobs has become the gold standard of mapping within public schools. Used appropriately in combination with the UbD and EL approaches, it can provide an effective platform to organize, maintain, and communicate curriculum design throughout the school and district, while playing a role in ensuring that standards are correctly aligned to these approaches.

Practical Implications

Bringing all of these bodies of knowledge together, we can begin to understand the complexities facing EL schools in implementing an effective curriculum mapping framework or solution. It isn't simply a matter of determining user requirements. The literature and research discussed here reveal concepts that are equally important in ensuring successful integration of curriculum mapping with a school's overall goals. It is therefore necessary to examine the practical implications of building and implementing an effective curriculum mapping solution built on EL, UbD, and specific school-based requirements. To do this we must first take a step back and examine the everyday challenges that exist in a typical school environment.

Cuban, Kirkpatrick, and Peck (2001) provided compelling insights regarding the challenges of successfully implementing and maintaining technology in K-12 schools. While their approach was more focused on teaching tools (instructional tools used directly in the classroom), it provided a realistic view of the challenges teachers face with regards to technology policy decisions. In their study, they found that access to new applications and technology did not necessarily translate to high usage within the classroom. Their findings revealed that most teachers seldom used the new applications or tools provided, and also found that they had little or no effect on teaching practices overall. This was due to two main problems: first of all, the technology studied in this article appeared to be plagued with the typical bugs, issues, network problems, and other common IT challenges that schools face on a regular basis. The second problem had more to do with integrating the tools into teachers' existing workflow and environment, which proved to be more of a challenge than the policy makers had anticipated.

The teaching environment in a typical K-12 school provides many challenges to teachers, who are often involved directly with classroom management issues, addressing high-needs students, ensuring lessons keep up with the scheduled pace, and providing the needed instructional experiences for all students. What is not often considered are all of the other tasks that a teacher needs to do during the day. Some of these involve floods of emails, staff team meetings, curriculum planning activities, assessments and grading (particularly since such systems are commonly not accessible from home), interruptions from parents or guardians, and scheduling conflicts. When the school day ends, teachers will often stay longer to ensure they have completed their regular daily task lists.

According to a recent poll carried out by the National Education Association, roughly 46 percent of teachers claim that they work more than 20 hours per week outside of the classroom, while nearly 31 percent of the respondents claim that they work from 11-20 hours in addition to classroom time. The teaching environment itself has experienced a massive impact in recent years, with budgetary cuts and increasing class sizes further adding to the overall workload (Hart, 2011). It is important to understand the current challenges facing educators in K-12 environments in order to consider whether or not a certain technology or process will likely be adopted and ultimately be successful.

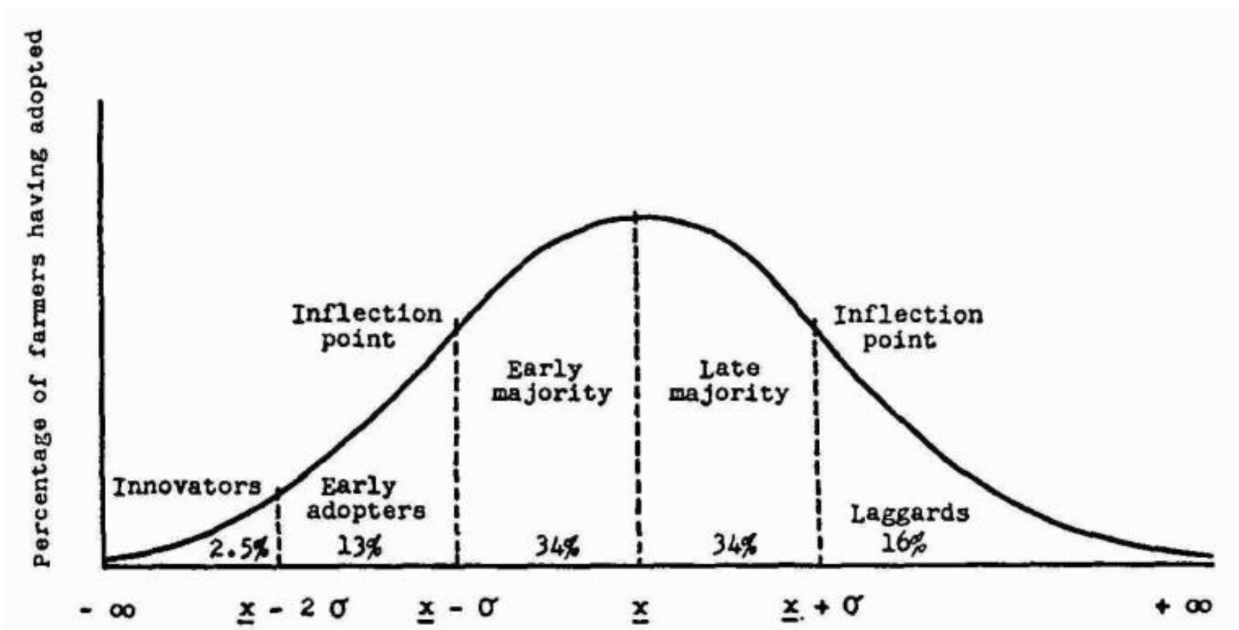
With so many challenges facing teachers on a day-to-day basis, coupled with little or no time to take on additional tasks or to learn new tools and processes, it is hardly surprising that technology adoption within schools continues to be a challenge. There are many articles about this problem in the academic world. One such article featured in *THE Journal*, an online educational publication, is titled “Resistance is Futile” (O’Hanlon, 2009). It examines why the challenge of adoption remains a problem within K-12 institutions. The article offers advice for improving the overall delivery of technology, providing better support and training, and giving incentives to encourage teachers to try out new applications and teaching tools. While somewhat informative, the article barely scratches the surface of what can be done in terms of practical implementation and improving adoption and acceptance rates.

Other challenges exist within the weekly schedule and the amount of time that teachers have to dedicate to new technologies and processes that are imposed on them. The larger issue of academic freedom must also be addressed when introducing new tools that influence the direction of curriculum or teaching within the classroom. There is a long history of litigation and changes in the way academic freedom has been interpreted over the years. Kraus and Stevens (2013) reviewed several court decisions that have directly affected teachers' rights to exert their power as subject-matter experts in the classroom, rather than merely becoming implementation facilitators. It has been argued that state-mandated core requirements and standards in themselves are restrictive to teaching and academic freedom; however, there is a fine line between carefully crafted curriculum and mere innovative teaching. An example of this problem is one of the "twin sins of design": teachers creating activity-based instruction (Wiggins & McTighe, 2005). Assigning fun and engaging activities without considering the overall goal or Common Core requirement is a fundamental problem with this approach. At the same time, teaching should not be restricted to the point where the teacher simply becomes a facilitator, reproducing the work of the state in the classroom. As Kraus and Stevens (2013) point out, this can be very dangerous when politically motivated legislators are in control of the curriculum. In one of their examples, legislation in the State of Texas forced conservative-leaning instruction within the district standards, which is both concerning and counteractive to the principles of academic freedom.

There are many schools of thought on why people accept or reject new concepts and ideas, and in order to gain a better understanding of these challenges, we need to turn to the literature. There has been much research over the years on acceptance and adoption of technology. It has become a very important area of study as the proliferation of technology has touched every part of our lives. Much of the literature stems from the early work on Dr. Everett Rogers' Innovation Diffusion Theory, which sought to explain why, how, and at what rate new ideas and technologies spread through cultures. In later years, research was carried out by Fred Davis, who created the Technology Acceptance Model, known as the TAM. Variants have sprung up since the TAM was originally published, and Davis and other colleagues have combined modified approaches to come up with the more recent Unified Theory of Acceptance and Use of Technology (UTAUT). Each of these theories will be examined in more depth.

Diffusion of Innovations (DoI) describes the study of how new ideas and practices spread within and between communities. Typically this spread (or diffusion) takes a long time, as many individual, societal, cultural, and technological factors influence the speed. The classic study carried out by Ryan and Gross in 1943 started much of the research within this field. Ryan and Gross retrospectively researched the spread of agricultural use of hybrid seed corn among farmers in two communities in Iowa. The hybrid seeds were developed at the beginning of the 20^{th} century and eventually replaced the process of replanting saved seeds, which farmers had traditionally done. This diffusion took time, however, while the seed manufacturing locations were being set up. Farmers started to use the new seeds slowly at first, mixing them with existing seeds; over time, farmers used them at an increased rate. Eventually, all the farmers within the communities used the hybrid seeds, after an adoption period of roughly 14 years. The key contributing factor in the adoption of this new way of farming came about through interaction with neighboring farms. Those who adopted the new seed shared its success with others, who eventually saw the benefits (Valente & Rogers, 1995).

The Ryan and Gross study was quickly followed by other studies that examined aspects of the innovation diffusion process. Many of these studies and subsequent findings were closely associated with the agricultural revolution in the United States (Stephenson, 2003). During the 1940s through the 1960s, other researchers analyzed and plotted mathematical curves that represented the adoption of agricultural innovations. Along with this, categories were created for the different types of adopters. The most well-known classification of adopters was developed by Rogers in 1958. He calculated the mean for the adoption curve and then, by adding and subtracting one standard deviation each way, he divided it into the five segments displayed in Figure 3. These classifications of adopters are summarized in Table 4.



(Rogers, 1958)

Figure 2 - Categorizing Adopters Graph

Table 4 - Categorizing Adopters Classification Summary

Innovators	Small in numbers, this group includes those who are visionary, imaginative innovators. This group spends much time developing new ideas, which can often be daunting to the more pragmatic majority.

Early Adopters	Early adopters typically include those looking to make strategic leaps in their lives or businesses, using those innovations for which the benefits are becoming apparent.
Early Majority	This group contains pragmatists, comfortable with moderately progressive ideas, but hesitant to act without solid proof or clear benefits.
Late Majority	These conservative pragmatists are uncomfortable with risk and the idea of not fitting in with the norm. Often this group is influenced by the fears and opinions of laggards.
Laggards	Laggards hold out until the very end until and remain critical of new innovations or processes.

(Rogers, 1958)

According to Rogers, technological innovation is communicated through particular channels over time and among members of a social system. Within this social system, peer-to-peer conversations and peer networks are fundamental to diffusion. Robinson (2009) summarized Diffusion of Innovations this way: “Instead of focusing on persuading individuals to change, it sees change as being primarily about the evolution or ‘reinvention’ of products and behaviors so they become better fits for the needs of individuals and groups.” Diffusion of Innovations essentially examines whether the user or potential user perceives a specific innovation as being better (or more beneficial) than the current idea it is meant to replace. This allows the qualities that make innovations spread successfully to be explored. Dr. Rogers provided a list of qualities that enable innovations to spread, shown in Table 5.

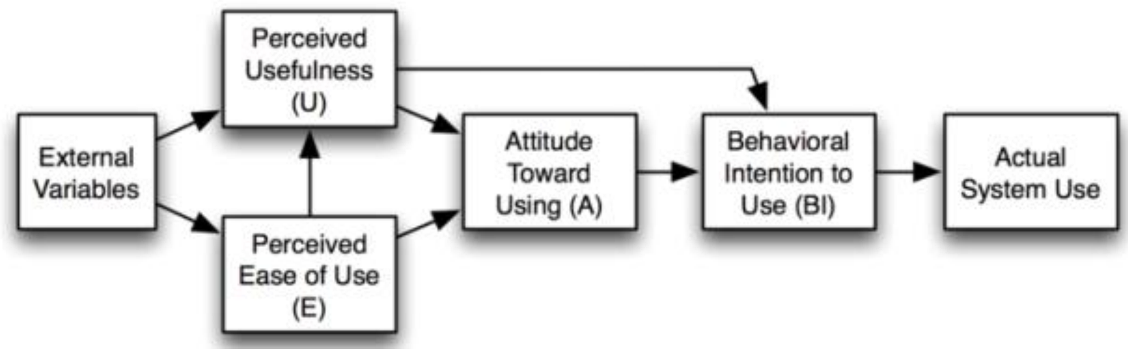
Table 5 - Qualities that Enable Innovations to Spread

Relative advantage	Extent to which everyone’s job becomes easier.
Compatibility with existing values and practices	Degree to which an innovation is perceived as being consistent with the values, past experiences, and needs of potential adopters.
Complexity or Simplicity	Overall ease of use.
Trialability	Degree to which an innovation can be experimented with, e.g. prototypes.
Observability	The easier it is for individuals to see the results of an innovation, the more likely they are to adopt it.

(Robinson, 2009)

By understanding the unique characteristics of potential user groups and the qualities that enable innovations to spread, this theory can be applied to modern tools and innovations in order to influence as well as predict adoption patterns. Diffusion of Innovations paved the way for other research in the area of acceptance. This included the Theory of Reasoned Action, published by Fishbein and Ajzen in 1975. According to the TRA, one's behavioral intention affects one's actual behavior. The TRA has become widely recognized in the area of psychological studies and since it was introduced, it has received a considerable degree of support and recognition (Mei-Ying, Han-Ping, Yung-Chien, & Yen-Han, 2011).

Findings derived from the TRA were developed by Fred Davis into a widely used theory that models how users come to accept and use technology. In his 1989 publication, "Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology," Davis introduced the Technology Acceptance Model (TAM) and provided a theoretical context that explained the relationship of attitudes, intention, and behavior, along with how these factors influenced acceptance of technology. Davis used the TRA to explore the relationship among perceptions, factors of affections, and technology usage. Like the TRA, Davis's TAM considers that attitude and intention are determinants of beliefs. He proposed that two specific variables—perceived usefulness and perceived ease of use—are fundamental determinants of user acceptance. Davis described *perceived usefulness* as the degree to which a person believes that using a particular system would enhance his or her job performance. *Perceived ease of use,* on the other hand, was described as the degree to which a person believes that using a particular system would be free from effort.



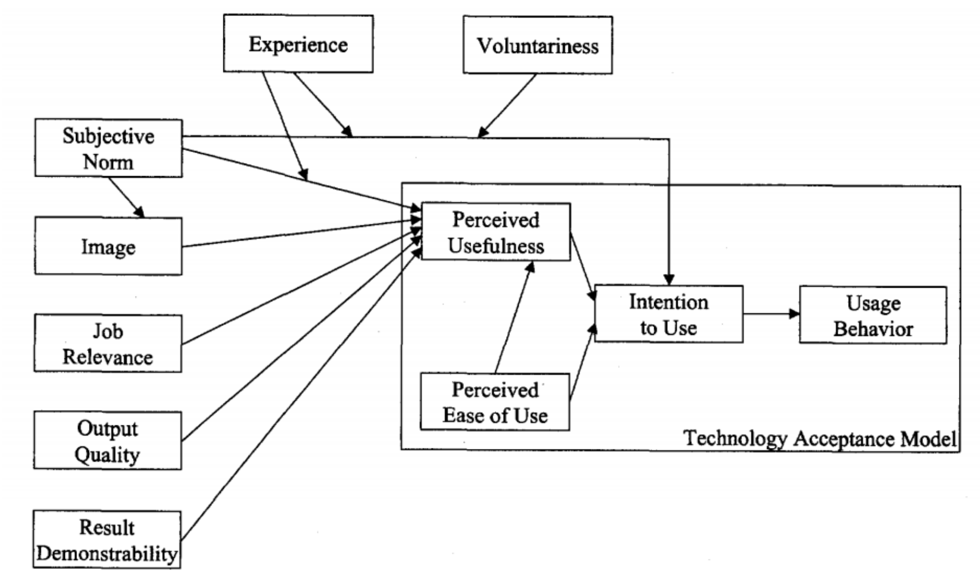
(Davis, 1989)

Figure 3 - The Technology Acceptance Model

The TAM suggests a causal relationship between perceived usefulness (U), perceived ease of use (E), attitude toward computer usage (A), and the behavioral intention to use (BI) as shown in Figure 4. The model demonstrates that a user's attitude towards new technology or a computer application is simultaneously influenced by the perceived usefulness and perceived ease of use of this same resource. The higher the overall perceived usefulness, the more positive the overall attitude toward using will be, which directly affects behavioral intention to use.

The Technology Acceptance Model has been used many times since it was published in 1989. Confirmation of its findings has been evidenced over the years through studies conducted using control groups and standardized surveys soliciting information on perceived usefulness and perceived ease of use. Since the model first appeared, modified versions of the TAM have been released. The TAM 2 was released in 2000, and later models have also surfaced. More recently, Davis created the Unified Theory of Acceptance and Use of Technology (UTAUT) in collaboration with other researchers, who brought together some of the qualities of other models and combined them.

Venkatesh and Davis (2000) developed the Technology Acceptance Model 2 (TAM 2), which was based on the original TAM. Two new sets of processes—the social influence processes and the cognitive instrumental processes—were added. The new social influence processes included the factors of subjective norm, voluntariness, and image, while the cognitive instrumental processes combined job relevance, output quality, result demonstrability, and perceived usefulness. How these processes relate to the original TAM model is shown in Figure 5.



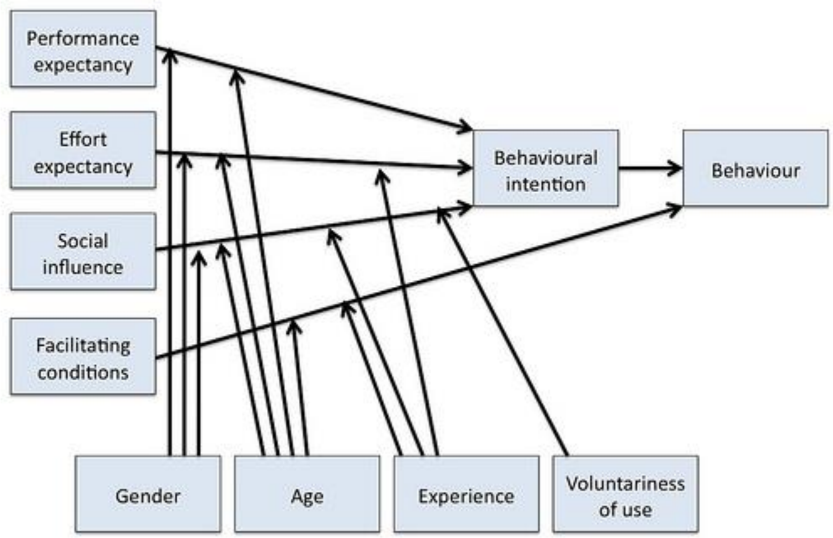
(Vankatesh & Davis, 2000)

Figure 4 - Technology Acceptance Model 2

Vankatesh and Davis realized the powerful nature of the social influence processes, which was why these were added to the model. *Subjective norm* originated in the Theory of Reasoned Action as a key determinant of behavioral intention. Fishbein and Ajzen defined this as "a person's perception that most people who are important to him think he should or should not perform the behavior in question" (1975). A modern-day example of this can be seen in the influences of teenage peers on the desire to buy a certain type of cell phone because of current popularity. Other examples could include fashion trends and desired types of cars, based on the perception of popularity. Another important social influence process that was added to this model was *voluntariness*, which refers to whether adoption of a specific technology was either forced or non-mandatory. Drawing from research on Diffusion of Innovations, Moore and Benbasat (1991) define *image* as "the degree to which use of an innovation is perceived to enhance one's status in one's social system" (as cited in Venkatesh & Davis, 2000).

In the new cognitive instrumental processes, *job relevance* was added as a key component, which describes the potential user's perception regarding the degree to which the technology or new system is applicable to his or her job. *Output quality* is defined as the degree to which an individual believes the new system can accomplish or perform the required tasks. Finally, *result demonstrability* gives the potential user results that are readily discernable, which directly influences perceived usefulness (Mei-Ying et al., 2011).

In 2003, Vankatesh, Davis, and several other researchers published the Unified Theory of Acceptance and Use of Technology (UTAUT) in "User Acceptance of Information Technology: Toward a Unified View." The UTAUT combined components of other models and addressed four key constructs: performance expectancy, effort expectancy, social influence, and facilitating conditions. These factors, the researchers asserted, were direct determinants of usage intention and behavior, as shown in Figure 6 (Venkatesh, Morris, Davis, & Davis, 2003).



(Vankatesh et al., 2003)

Figure 5 - UTAUT Framework

Vanketesh et al. (2003) described *performance expectancy* as the degree to which an individual believes that using the system will help attain gains in job performance. *Effort expectancy* was described as the degree of ease associated with the use of the system. This factor captured the concept of perceived ease of use from the original TAM. *Social influence* in the UTAUT was described as the degree to which an individual perceives the importance of others' belief that he/she should use the new system. This draws concepts from image and subjective norm within the TAM 2. Finally, *facilitating conditions* refers to the degree to which an individual believes that an organization and technical infrastructure exist to support the use of the system.

While the TAM 2 and UTAUT built upon the original TAM, the simpler TAM model is still widely used within organizations to measure acceptance probabilities. How, then, can the TAM and its modified versions address adoption in regards to an application designed for curriculum mapping in an Expeditionary Learning setting? In order to answer this, we must again turn to the literature and look at examples where acceptance models have been used to accurately predict adoption patterns.

One of the better-known cases of using a modified version of the Technology Acceptance Model was carried out in Mumbai and Delhi, India. The findings were published by Thakur (2013). The study was developed to measure customer adoption of mobile payment services by working professionals. Data was collected using convenience sampling, with a total of 146 completed responses. The main research instrument used during the study was a survey method based around the factors detailed in Davis's original TAM publication. Findings indicated that facilitating conditions, social influence, performance expectancy, and effort expectancy all had a significant influence on behavioral intention to use mobile payment services. The study also indicated that behavioral intention was a significant indicator of actual usage.

A study of acceptance more closely related to the education field was carried out by Aypay, Çelik, Aypay, and Sever (2012). Research was carried out on Turkish teachers to determine the factors that influence technology acceptance. The results indicated that there was a good fit between the model and the data. In both this study and Thakur's study, the underlying research instrument was in the form of a survey, which included carefully crafted questions that helped determine the impact of various factors of the acceptance model in use. In both studies, control groups, or individuals who had accepted similar technology innovations in the past, were used in order to determine the overall accuracy of the instrument.

While the TAM, TAM 2, and UTAUT are the most commonly used acceptance models, there are also other issues in this area that should be considered. Computer anxiety can sometimes have an effect on self-efficacy and therefore become a barrier to acceptance. Simsek (2011) researched computer anxiety among students and teachers, and discovered that younger students were less anxious than older students, and that teachers were generally overall more anxious than the students in the study. According to Simsek, research tended to support that more experiences with computers reduced the level of anxiety. This was particularly true when students started using computers at early ages, owned a personal computer at home, used computers more frequently in daily life, and pursued an academic major that was technical in nature.

A much earlier study carried out by Russell and Bradley (1997) researched computer anxiety among teachers. Their study concluded that appropriately funded and targeted professional development of computer skills was necessary. While nowadays most teachers are familiar with basic desktop computing tools, considerations for adequate support should still be made when introducing new technology solutions to a teacher population.

Other literature in the area of adoption focuses on buy-in strategies, which are essentially ways to improve the overall likelihood of adoption within the organization or school. The U.S. Department of Education released a publication on this topic, listing a set of strategies to increase the chances of adoption success within the school. In their article they emphasized creating a core group of "early adopters" in order to positively influence others within the school. Another suggestion was to reward teachers for designing good instructional use of technology. Goals should also be developed for technology skills (Singh & Means, 1994).

All of these areas of research should be taken into consideration when proposing a new curriculum mapping solution. An understanding of the importance of the social aspects of DoI, in addition to the different user segments, should be considered in the context of the school environment (specifically, how DoI operates on teachers, administrators, and parents). The UTAUT provides a good foundation for considerations that should be made beyond perceived ease of use and perceived usefulness. The social influence and demographic elements of this model lend it well to a teaching environment. In a school such as Monarch Academy, where the teacher population is relatively small, social influence can play a key part in software adoption. For this reason, not only is it important to have a user-centered approach to development, it is also vital to coordinate with and involve teachers at early stages of the design process. By bringing the user population into the development process, it not only becomes easier to learn about their unique needs, but it also gives them the opportunity to shape the project. These early activities help spur interest and buy-in as well as increasing social influence with other teachers and users.

Design, implementation, and long-term acceptance are all extremely important practical implications of integrating a new software application within a school environment. But one other area that should be taken into consideration is security. This is especially true when proposing to build or distribute any form of web-based application, regardless of its nature. If it is a public-facing application, there is a chance that harm could be brought about by malicious hackers. You don't have to look far to discover the severity of cyber-security attacks facing commercial, government, and educational organizations. In the education world, one of the more recent stories about this problem surfaced in the *Philadelphia Inquirer* in April 2013. In the Downington Area School District, funds of $665,000 were stolen in a cyber-attack; the money wound up in foreign bank accounts (Naedele, 2013). This is one of the few cyber-attack stories where the school managed to retrieve the stolen funds.

One of the most common ways web applications are compromised is through vulnerabilities that hackers can exploit via malicious code. Malicious code, often referred to as *malware*, is any piece of software designed to cause harm, theft, or unauthorized intrusion.

Bergeron et al. (2001) describe this malicious software as “pieces of code that can affect the secrecy, the integrity, the data and control flow, and the functionality of a system.” The two most common cyber-attacks come in the form of cross-site scripting and SQL server injections, which take advantage of vulnerabilities in the systems they target. Often these vulnerabilities are present because of poorly written code, where little or no thought has been given to system security. Vulnerabilities can also be caused by poorly configured servers or network firewalls. These types of vulnerabilities should be taken into consideration when developing software. To better protect the application, there are various scanning programs that will review the entire codebase of custom-built applications and produce a report highlighting vulnerabilities. HP WebInspect is a well-known security testing suite, which provides comprehensive scanning for enterprise-level applications. WebInspect examines many different forms of vulnerability, taking into account the latest technology trends and security breaches.

While understanding the threats and vulnerabilities, it is equally important to try to understand the attacker (often referred to as the threat actor or hacker) and also the attacker’s motivations. Hackers fall into many categories, from mischievous individuals who get a thrill out of causing disruption to websites, to career criminal hackers who make a living off their malicious behavior. Denning (2000) categorized several broad groups of motivation that can drive online behavior, including activism, hacktivism, and cyber terrorism. *Activism* involves any individual or group that uses the Internet in a non-disruptive way to advance a political cause or agenda. Young (2001) describes an activist as an individual who promotes an agenda, which they may term a “greater justice,” to affect the beliefs and motivations of others. Activism, which traditionally has focused on non-Internet activities, has moved into the online space in recent years. On its own, it is typically benign; however, the marriage of activism and hacking can result in more harmful activities. *Hacktivism* involves individuals who disrupt normal operations in order to get across a political, social, or religious point or message (Siciliano, 2011). The most extreme form of hacktivism is cyber terrorism; instead of merely causing disruptions, cyber terrorists target critical infrastructures. Denning (2000) describes *cyber terrorists* as those that seek to harm or cause chaos through a convergence of cyberspace and terrorism.

With a better understanding of the types of hackers and the motivations driving them, it is important to consider which of these groups will most likely target educational institutions within the context of a curriculum mapping application. While other systems within a school may contain Personally Identifiable Information (PII), a curriculum mapping system would only contain information about the school's curriculum and schedules. There is no monetary gain to be obtained by criminal hackers who would seek to target such a system, unless there was a way to use it to gain access to other internal systems. The most likely perpetrator would be one who would fall under the "hacktivist" category and would have either a personal or political agenda to target such a system. Whether this would be mainly in order to cause the school embarrassment by defacing a public-facing web application or for the "thrill" of breaking a system, considerations still need to be made for security, even though the nature of a curriculum mapping application makes it less of a target.

Summary

This chapter reviewed the body of knowledge around curriculum standardization, curriculum mapping, Expeditionary Learning (EL), planning frameworks, and the practical implications of implementing a curriculum mapping solution with consideration for the teaching environment, adoption, and security. Implementation of a successful curriculum mapping application goes far beyond the initial design stage of the project. The research covered within this chapter is an essential building block for understanding the complexities such a system poses within the context of EL.

Curriculum standardization and Common Core are the driving force behind most curriculum mapping initiatives. The unique characteristics of Monarch Academy's Expeditionary Learning model have been shown to introduce complexities into the mapping process. Monarch Academy uses an outcomes-based approach to planning, utilizing the Understanding by Design (UbD) framework; therefore, any proposed system must allow for this approach. An understanding of the teaching environment, which can come only in part from literature, must be at the forefront of any development activities. Long-term acceptance or adoption will be the ultimate measure of success. By involving teachers in each development phase of the project, the risk of non-acceptance will be mitigated, if managed correctly. Finally, other concerns with distributed web applications should be examined, including infrastructure and security.

Chapter 3: Methodology

This chapter will outline the various research methods that were used to fill some of the gaps in the existing research in order to gain a better understanding of Monarch Academy's unique requirements. Much of the new research carried out during this study involved direct collaboration with the school's administration team, teachers, and staff over a nine-month period of time. The information obtained, used in combination with the existing research, had a direct impact on the design of the curriculum mapping solution—designated *Expedition Mapper*—that was produced for use at Monarch Academy.

There are a number of methods that are popular in the research area of user-centered design. Most of these methods involve direct interaction with the target user audience to determine overall requirements, while ensuring ease of use and overall usefulness of the proposed system. Both ease of use and usefulness were discussed in Chapter 2 as the two main tenets of the Technology Acceptance Model (TAM). How the user perceives both of these has been shown to have a big impact on the overall adoption rates of new technologies and software solutions. Taking this further and exploring the Unified Theory of Acceptance and Use of Technology of the UTAUT model, we can see there are many other influences at work, including social and demographic conditions. In a school environment, these additional factors need to be considered when building an application that *should* eventually be adopted by teachers and staff. In order to do that, performance expectancy, effort expectancy, social influence, and other facilitating conditions must be considered when choosing methods for user-centered design. To carry out full experiments using these models would require a much larger sample size of users, which goes beyond the scope of this study; however, these conditions should still be at the forefront of any methods used.

User-Centered Design (UCD) offers many different approaches to gathering data and analyzing ways to ensure that proposed solutions are built with the focus on user needs and interactions. Vrendenburg, Mao, Smith, and Carey (2002) reported on the results of a survey of user-centered design (UCD) practitioners. The survey involved over a hundred respondents and identified the most widely used methods and processes at that time. Respondents were asked to "identify several of the most commonly used UCD methods in your practice." They were also asked to "rank the five most important UCD methods on the basis of their actual impact on product development (e.g., user satisfaction, results in the market, and cost savings)."

Five of the UCD methods were considered "commonly used," as they were mentioned by about a third or more of the respondents (a minimum of 28 percent). These methods were iterative design, usability evaluation, task analysis, informal expert review, and field studies. All but one of these five methods were believed to have the most important impact in practice, as reflected in the average ranking score. Although informal expert review was widely used (likely because of its low cost), it was not considered to have a high impact. In contrast, user requirements analysis, which is typically more expensive and difficult to do, was mentioned by only few people as being commonly used, but it was considered very important in practice by those few who used it. It appears, in both cases, that respondents were mindful of a strong cost-benefit tradeoff.

For the purposes of this study, the decision was made to triangulate multiple methods of data collection commonly used in the field of user-centered design. Focus was placed on an iterative approach to design and development (including prototyping), along with usability evaluation, solicited teacher feedback, and observations.

Iterative Design Process

This study used a number of Agile processes to collect information for the iterative design process. *Agile* is a software development methodology that is based on iterative and incremental development. One type of Agile process, called Scrum, is a project management approach built around meetings or “sprints,” where a group of people devise a list of items or tasks to be completed by the next sprint. Sprints typically last no longer than one month. Scrum typically involves a product owner, a Scrum master, and a team of developers. The idea is that the software is developed in increments, with the result that the client has a much clearer picture of where the product is headed. Agile also increases communications, while minimizing the overall risk sometimes associated with more traditional “waterfall” methods. Design flaws can be revealed early on and resolved iteratively. In this study, a less formal implementation of Scrum was adopted, since the researcher took on the role of both the Scrum master and the developer.

Another Agile method for managing projects is called Kanban, which was used in this study to complement the Scrum process. Kanban originates from Japan and is most commonly known for its roots in JIT (Just In Time) manufacturing. The word *Kanban* is Japanese for “signboard or visual signal.” In the 1940s, JIT grew out of Toyota's cultural commitment to continuous improvement to spur peak performance in its manufacturing processes (Ordysiński, 2013). Kanban has become very popular in recent years within software development. Companies like Leankit provide online electronic Kanban boards as services to project teams. A typical Kanban layout will be comprised of multiple sections of a project (sprints), with three columns in which to place cards: to-do, in process, and completed. This type of visual task management system benefits all stakeholders within a project. Leankit’s Kanban, which was used during the study (see Figure 7), not only enabled self-documenting tasks, but also provided an additional level of communication between the researcher and stakeholders.

Figure 6 - Leankit Kanban Board

During the Agile process, a number of meetings took place with several personnel from the school. This group of people included key administrators and teachers who had been involved in the curriculum mapping process at Monarch Academy. The initial meeting consisted of a high-level discussion of what the school needed. This was followed some months later by six sprint meetings about iterative requirements. At each of the sprints, a prototype was presented and modified, based on previous discussion, and then refined again for the next sprint, based on the assigned set of tasks or changes. These tasks formed “stories” or broader picture goals.

Axure (an application described in more detail in the “Prototyping” section of this chapter) was used to draft the initial prototypes; however, as the requirements and business rules became more complicated, a more sophisticated prototype was developed using a server-side programming language and back-end database. Once this system had been refined, based on discussions in the sprints, the next phase included user testing. An initial pilot test was carried out in the University of Baltimore's usability lab. The pilot revealed several issues with the questions: they were too restrictive, causing the participant to complete the test rapidly but with little depth or understanding of problems with the design. Some software bugs also persisted in the pilot, which were later corrected for subsequent tests.

During the time the sprint meetings were being held, observations were planned in order to gain a better understanding of the lesson and curriculum planning processes teachers go though each semester. These observations were carried out during teacher planning times and provided additional insight into the process EL teachers follow to prepare for lessons. Field surveys supplemented the study by providing additional feedback directly from the teachers. Open-ended questions were used in order to gain a clearer understanding of current processes at the school. The survey also helped gauge desired perceptions of a curriculum mapping application that would replace the manual process currently being used.

The various methods used throughout the study are highlighted in the timeline shown in Table 6. There is a noticeable gap between the initial kick-off meeting and first requirements sprint; this was due to time constraints in both the school semester structure as well the additional lead-time needed to produce the first prototype.

The project officially started on April 10, 2013, with an initial kick-off meeting with administrators and teachers at Monarch Academy. During the summer months between June and August, the first high-level prototype was developed. A series of six sprint meetings took place at the school, starting in the fall semester. A field survey was conducted in December at a

Table 6 - Research Methods: Iterative Development Timeline

Iterative Design Activities →

	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Agile Sprints	Kick-off					Requirements Sprints 1-6					
Prototypes			High Level Prototype				Axure Prototypes		ASP.Net		
Field Surveys									Teacher Feedback		
Observations										Curricular & Team	
User Testing									Pilot	Remote Testing	

professional teacher development meeting. Usability testing also started in December, first with a pilot study, followed by ten remote usability test sessions. In addition to this, several observations took place in early January. For a complete timeline of all research activities, please refer to Appendix A. A copy of the letter granting approval for the research from University of Baltimore's Institutional Review Board may be found in Appendix B. A more detailed explanation of each of the research methods used throughout the study follows in the remaining sections of this chapter. An analysis of the findings is documented in Chapter 4.

Requirements Sprints

In April 2013, an initial kick-off meeting took place at Monarch Academy. The researcher had been in contact with the school to schedule a time to speak with the key stakeholders of the curriculum mapping process at Monarch Academy. This group, known as the Curriculum Mapping Steering Committee (CMSC), was comprised of an administrator, a representative from Expeditionary Learning, and two teachers. The purpose of the kick-off meeting was to introduce the researcher to the stakeholders and gain an understanding of their current process (see Appendix C for the meeting's Question Script). In the months that followed, a prototype was drafted, based on observations from the kick-off meeting. This prototype served further discussions in the sprint meetings that were held during the Fall 2013 semester at Monarch.

In the fall, six sprints took place between September and December. Each sprint ended with a *user story* (an overall goal for development enhancements), which was then divided into a number of tasks. Each task was added to the Kanban board, which the researcher then completed prior to the next sprint. The first sprint focused on creating a high-level requirements story, with the prototype serving as a platform for further discussion and brainstorming. This story described a high-level set of assumptions about the nature of basic data elements. These enhancements were made in time for the second sprint, which more clearly defined expeditions, their purpose in the school, and the various data elements needed for collection. The third sprint was focused on clarification of two different semesters—First Six Weeks (FSW) and Winter Term—which did not fit into the standard expedition structure. The fourth sprint involved discussion on subject areas not compatible with an expedition and which had their own set of business rules. These first four sprints lead to a clear definition of inputs and data elements to be captured in the system, while the fifth and six meetings focused on the outputs. The fifth meeting transitioned into discussions of mapping and reporting capabilities. The sixth meeting continued the discussion of reporting and clearly defined search, faceting, and reporting expectations. More details on the outcome of these meetings, along with the documented stories, are given in Chapter 4.

The sprints provided a clear Agile structure for building wireframes, which later transitioned into a more advanced interactive prototype. They also served as a platform for teachers and administrators to voice their concerns and their sometimes conflicting needs. To maintain a continual stream of communication between the researcher and the team, a blog was set up in addition to the Kanban board. The blog contained notes on each of the sprints, along with archives of completed tasks and stories (Figure 8). Each sprint was recorded, and the blog provided audio copies of the sessions, so the committee and researcher could go back and review previous discussion when needed.

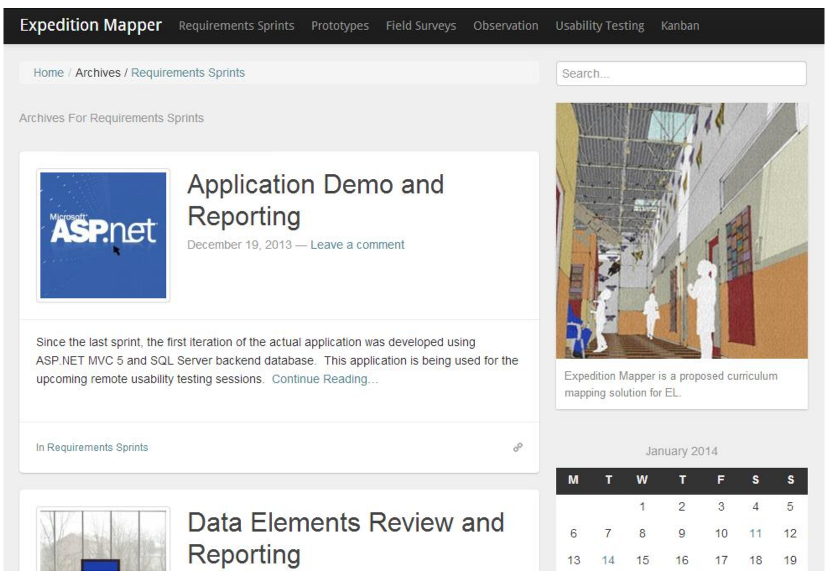


Figure 7 - Expedition Mapper Blog

The benefits of the sprints included more focused discussion, clear targets, and task lists or user stories. There was, however, one drawback: due to the small number of people on the committee, it was difficult to ascertain whether or not all stakeholders' needs were being accounted for. The other stakeholders included all teachers, administrators, and staff outside this group, who would eventually be expected to adopt and use the proposed system. Field surveys, observations, and usability tests by other personnel at the school helped to ensure that other voices were heard during this process.

Prototyping

Axure is a prototyping application that is commonly used in the field of user-centered design. It provides an effective way to rapidly develop web-based wireframes and interactions that can serve as a platform for user testing and Agile development. In this study, Axure was used to develop six basic prototypes. The first was created after the initial kick-off meeting and complemented the initial high-level requirements discussion. As other sprints followed, sets of tasks and stories shaped the prototype, and new versions were developed and refined (Figure 9). The prototypes were made available on the blog, allowing the committee to interact with the prototype between meetings, which aided in the requirements discussion.

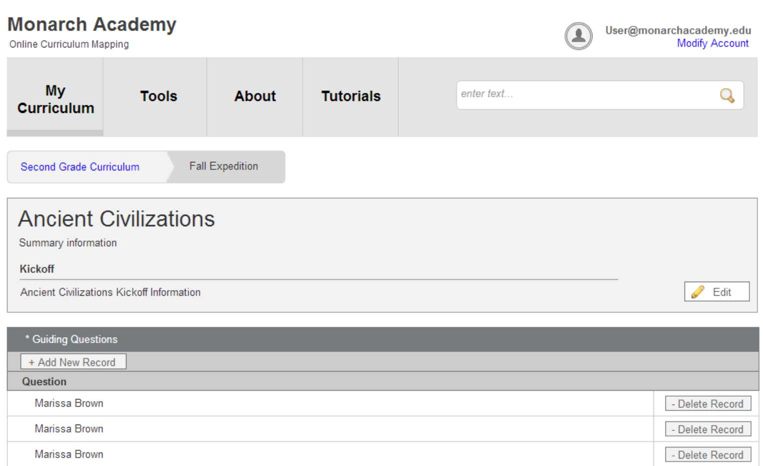


Figure 8 - Axure Prototype 6

While the Axure platform was helpful for making rapid changes and enhancements to the design, it also proved very limited. It was extremely difficult to prototype interactions that involved saving state, using advanced dynamic features such as HTML5 grids, responsive design, and modern user-interface components. The initial prototypes served the study well until the process of creating workarounds to replicate real components became too cumbersome. When this happened, the researcher made the decision to build later designs using the Microsoft ASP.NET server-side programming language, with a database back-end, and with real JavaScript front-end components. The ASP.NET application was used later on for user testing, which allowed the use of the more advanced features of the system.

The system incorporated Microsoft's Model View Controller (MVC) framework and included the Kendo UI JavaScript library for interactive front-end controls. The structure of the relational database is shown in the diagram in Appendix D. The database was designed using a code-first approach, whereby each table was written in C# as an object and associated through an Object Relational Mapper (ORM). More details and explanations of both the architecture and supporting libraries are provided in Chapter 5. This system allowed for more realistic interaction, storage of user-entered data, and a responsive flat UI design that is compatible with mobile devices.

Field Interviews

Through the coordination of the Curriculum Mapping Steering Committee (CMSC) and the administration team at Monarch Academy, a curriculum mapping professional development workshop was arranged. Invitations were sent out to Monarch's elementary and middle school teachers. Specialized subject teachers and IT staff were also invited to join the workshop. The researcher requested a diverse set of users in order to obtain different feedback and opinions during the session; however, the population pool was small to begin with. Regardless of this challenge, over 20 teachers and staff attended the workshop.

The researcher presented a short overview of curriculum mapping and the proposed system that was being developed. Each teacher was handed a short survey to complete, with five open-ended questions and a series of multiple-choice questions (see Appendix E). After the presentation was over, the teachers were split into three groups. The researcher led one of the groups, while two of the CMSC members led the other two. In these smaller groups, teachers were asked to continue their thoughts regarding the survey questions and to elaborate on what they wrote. Each of these sessions was recorded. The results of the surveys were entered into a spreadsheet for further analysis.

Usability Testing

Beginning in December 2013, a series of usability tests on the ASP.NET application was conducted with the help of Monarch Academy teachers. Each participating teacher signed a consent form (Appendix F). A script for the usability test appears in Appendix G. The initial pilot test was conducted at the University of Baltimore's usability lab. The pilot test revealed a few minor bugs with the application, which hindered the test session. In addition to this, it was discovered that the questions lacked enough depth to fully test the system. The questions were modified before the next set of participants was tested.

Subsequent tests were conducted remotely. This enabled the researcher to solicit more participants from among those who would not have been able to attend a session in Baltimore. In total, ten remote usability tests were conducted over a period of four weeks. The teachers who participated were awarded $25 Amazon gift cards for their time. Prior to each session, the database was reset in order to produce the same starting point for each participant. Each of the remote tests was carried out within 20-30 minutes in total, including time at the end for additional open-ended questions.

The remote web-conferencing application, Join.me, was used for all remote testing sessions (Figure 10). This enabled the researcher to record each session for later analysis. As the tests were carried out, a series of reoccurring issues and themes surfaced, which enabled the researcher to plan for improvements. More details about these themes and other identified issues are documented in Chapter 4.

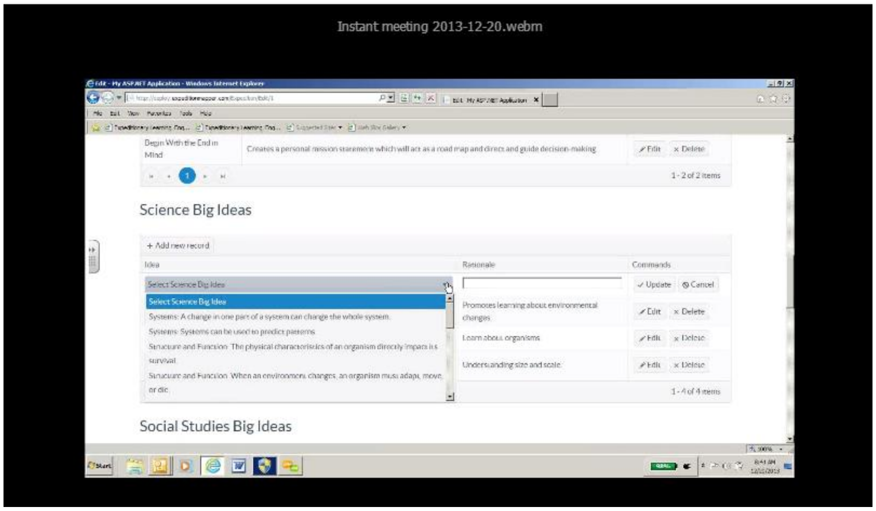


Figure 10 - Join.Me User Testing Session

Observations

Two observations were scheduled. One was at the school's curriculum planning meeting, which is held twice a year to define and plan for expeditions in the following semester. The second observation was held at a meeting of the second-grade teaching team in order to gain a better understanding of the more detailed week-to-week lesson planning within an expedition. The purpose of the observations was to study the macro process of expedition development and the micro process of grade-level planning. While the school's main expedition planning meeting only occurs twice a year, the grade-level teams meet more regularly, typically once per week. Each week these teams hold a planning session to discuss upcoming lessons, current challenges, and other related expedition and subject-matter content. Findings from these observations, along with the other findings of this study, are documented in chapter 4.

Chapter 4: Results and Analysis

The final prototype developed during this study served as an alpha version of the Expedition Mapper software (Chapter 5 documents the architecture and technical considerations of that system), which the researcher plans to develop further for eventual deployment at Monarch Academy. The activities and research leading to the final prototype involved an iterative development process in partnership with the stakeholders at the school. This process was built around the project methodology, involving several forms of research, including sprint requirements meetings, prototyping, field interviews, usability testing, and observations. The results provided analysis of the overall stakeholder influence, which ultimately guided design decisions throughout the process. This chapter breaks these results into three main sections: Key Stakeholder Influence, Workflow Analysis, and Teacher Involvement, as shown in Figure 11.

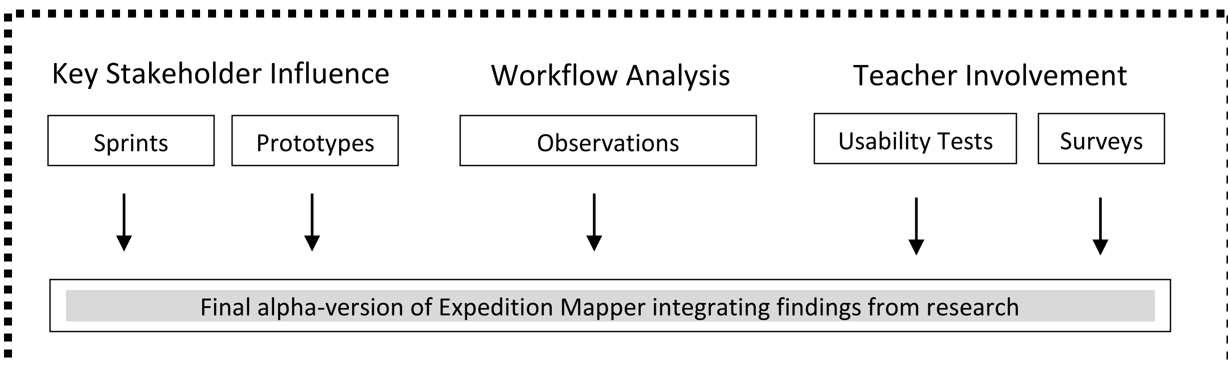


Figure 11 - User-Centered Analysis Themes

Key stakeholders, including the Curriculum Mapping Steering Committee (CMSC) and administrators, exerted their influence throughout the sprints and prototyping phase of the project. In order for the researcher to gain a better understanding of the needs of the school in any comprehensive curriculum mapping solution, observations were carried out. Finally, teacher involvement was present throughout the project in the form of field surveys, usability testing, and select membership in the CMSC. This chapter focuses on these three main sections and provides an analysis of the insight gained by the researcher, which ultimately led to and influenced design and functionality changes in the final application.

Key Stakeholder Influence

A total of six sprint meetings took place between September and December of 2013, which were held in parallel to other ongoing research activities. Each sprint involved discussion, which led to user stories and task lists. These task lists were later documented in a Kanban board. *User stories* are one of the primary development artifacts from the Scrum and Extreme Programming (XP) methods of development (Lu & Lu, 2013). They are essentially high-level requirements artifacts that can be further broken down into specific coding tasks. During any given sprint, two to five user stories would be defined during the meeting. The researcher would take these user stories and decompose them into specific tasks, which would then be carried out in the next iteration of the prototype, as seen in Figure 12.

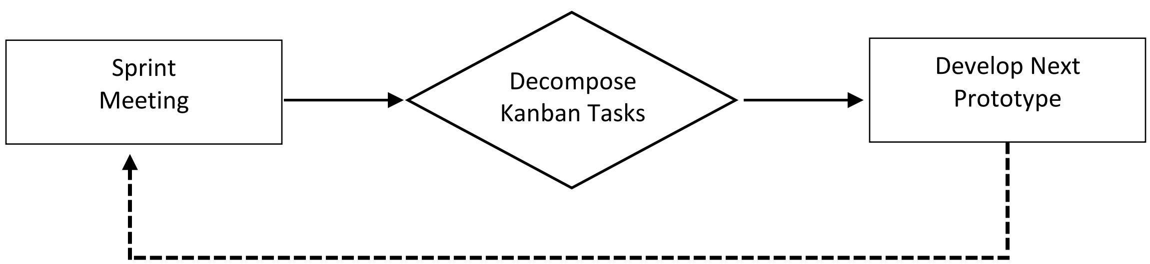


Figure 12 - Iterative Agile Process

This cycle continued for six sprints. At the beginning of each sprint, the prototype changes resulting from the previous sprint were first discussed, and then decisions were made on aspects of the application. Using a process of progressive elaboration, the CMSC further refined and decomposed requirements at each meeting. The sprints resulted in the development of six static Azure-based prototypes and one interactive prototype built on the server-side technology of the final application.

Prior to the sprints, a very early set of wireframes was developed after the researcher met for the first time with the CMSC at a kick-off meeting. These wireframes served the purpose of shaping the discussion of the first sprint meeting. The first few sprint meetings focused on high-level requirements and the definition of expeditions, as well as First Six Weeks (FSW) and Winter Term (or mini-semesters). The purpose of these meetings was to develop an understanding of the basic data elements needed for their curriculum mapping process.

The first sprint revealed some flaws in the design of the initial prototype. It provided insight to the researcher on how the various expedition data entry elements should be captured. A greater understanding of the role of case studies was also gained in this first sprint. The analysis led to a redesign of the basic expedition data entry forms.

Problems with the next stage of design were revealed during discussions in the second sprint. The concept of different expedition types (First Six Weeks, Winter Term, etc.) did not fit into the prototype, so modifications were proposed. As more details on expedition data elements were exposed, the researcher gained a clearer understanding of what was needed.

As the prototypes became more advanced, other requirements surfaced. During the third sprint, a discussion took place about subject areas that did not fit into a typical expedition. Up until this point, the researcher's design was built and structured on expeditions as the top-level container for all data. This had to be completely reevaluated because of the need to collect data on non-expedition subject areas. This sprint led to another major milestone in understanding deeper and more complex requirements.

The whole concept of expedition vs. non-expedition holding areas for capturing data was further explored in the fourth sprint. The researcher gained a better understanding by further analyzing the differences in data with the curriculum mapping committee. The concept of a "strand" was introduced, which served as a naming convention for these non-expedition groups of data. As more details were revealed during these discussions, the researcher was able to build and refine more detailed prototypes.

The fifth sprint provided insight into areas of the system that had not yet been discussed. Up until this point, the focus of the conversation lay with data entry screens that teachers would use to effectively populate their maps. At this point, discussion took place on the reporting and administration sections of the application, in terms of what output was needed and what controls the Monarch administration team would need for defining selection or pre-populated data elements.

Further discussion of the system's reporting and expected outputs took place during the sixth sprint. It was apparent that more work would be needed in future iterations of the software. The administration team at Monarch wanted the capability to produce custom data sets of information, top-level views of aggregate data for gap analysis, and an easy and effective way to print these reports. The researcher gained valuable insight into the data analysis and reporting expectations of the team.

Appendix H provides a breakdown of each sprint that took place. In total, the 6 sprints yielded 14 user stories, and which decomposed into 28 Kanban tasks. These tasks were carried out, resulting in the development of six Axure prototypes and one interactive ASP.NET prototype, which was further refined and used during usability testing sessions. By taking an iterative approach to development, the researcher had the flexibility to change, modify, and update prototypes based on the ever-changing requirements of the CMSC.

It was evident in the early stages of this process that the key stakeholders did not completely understand what they needed in terms of a curriculum mapping solution. The Agile framework provided the perfect platform to develop and build the right solution based on user-centered needs and requirements. But beyond this group of key stakeholders, other potential users within the school had to be considered, including the rest of the teacher population. Findings from this population—as collected through observation of the teachers' workflow process, along with the teacher involvement established by field surveys and usability tests—have been documented in the sections that follow.

Workflow Analysis

Much of the research carried out during the study was focused on the end-user needs of the system. In order to fully understand these needs, a deep understanding of the current curriculum planning workflow had to be obtained. The field survey assisted with this process, and the sprint meetings served as a central part of the overall research; however, observations gave the greatest insight into both macro- and micro-level curriculum planning.

Prior to the start of each expedition, a cross-curricular meeting is held with different grade levels in order to share their proposed expeditions, solicit feedback, and cohesively work together to ensure a logical, stepped progression of the students' learning experiences from year to year. These meetings take place in three grade-levels groups, called hallway teams: K-2, 3-4, and 5-6. In addition to these larger scale meetings, weekly team meetings are carried out at every grade level; these focus on more detailed day-to-day lesson planning. The purpose of these meetings is to flesh out specific skills and concepts for upcoming weeks, and they would typically include specific materials, activities, demonstrations, and lessons that the team would use for planning and/or locating the resources needed.

The researcher observed the K-2 cross-curricular meeting for the spring expedition at the beginning of 2014. The cross-curricular meeting was structured in such a way as to allow each team to “pitch” their grade-level expedition to all meeting attendants. Those attendants included teachers from other grade levels, the school’s reading specialist, the instructional coach, and an administrator. The cultural arts team is also typically involved with these meetings; this team includes the music teacher, physical education teacher, and the media teacher, all of whom teach across grade levels. The involvement of these additional team members emphasized the importance of their role in the curriculum mapping process, revealing the need for them to have access rights to various different grade levels in the system. Up until this point, the researcher had planned to provide grade-level access only.

During the meeting, each grade-level team was given ten minutes to present their proposed structure for the spring expedition. This was then followed by a five-minute question-and-answer session, followed by another five-minute period for audience suggestions. These suggestions often yielded ideas for cross-collaboration or sharing of resources, such as expert visitors who might be able to assist within several grade levels. After all three teams had completed the process of presentation, question-and-answer session, and suggestions, the final portion of the meeting was dedicated to cross-grade-level themes. This part of the meeting tied together discussion from all three groups, identified common themes, and allowed for further discussion for improvement and ideas at this level. In the meeting the researcher observed, the kindergarten, first-grade, and second-grade teams presented their proposed expeditions. A brief summary of these proposals is outlined in Table 7.

Table 7 - Cross-Curriculum Meeting Team Expedition Proposals

	Kindergarten	First Grade	Second Grade
Concept	The blue crab and osprey.	The Monarch butterfly: Investigating its life and journey from the U.S. to Mexico.	Into the Woods: Creatures and ecosystem of a deciduous forest.
Final Product	Creating a coloring book that teaches about the blue crab and osprey.	Spanish and English calendar that shows the various stages of the butterfly's life. Sell to raise money to support conservation efforts of Monarch habitats.	Social media website spoof.
Experts	Crab fisherman. Ranger (specializes in osprey).	Entomologist.	Arborist.
Fieldwork	Baltimore Aquarium.	Butterfly house pavilion.	National History Museum: accompanied with the art teacher to sketch realistic animals.
Literacy Goal	Identifying beginning sounds and basic sight words related to crabs and osprey.	Writing descriptive sentences.	Writing a 5-paragraph essay introducing author's purpose researching activities.
Social / Sciences Goal	Labeling the body parts of the crab and osprey. Telling why they are important.	Impact of ruined habitats. Life cycles.	Interdependence within a food web. Ecological human footprint.
Math Goal	Counting to ten. Basic patterns.	Comparing numbers. Patterning (for making predictions for the future of Monarch butterflies).	Measurement and geometry: comparing creature sizes; using measurement to compare living things; geometry to quantify and describe living things in an ecosystem.

During each team's question-and-answer and suggestions sessions, several key issues surfaced, which had an impact on changes to the proposed expedition structure. At the end of the kindergarten presentation, discussion arose about the possibility of undertaking a classroom museum in place of the coloring book. The reason for this was because it was felt by a number of people that the coloring book simply did not show a deep enough level of learning when a similar final product based on this idea was used last year.

A similar concern arose after the first-grade team had presented, regarding their idea for calendars as the final product: there might not be enough evidence of the knowledge gained by the students. This was because the structure of the calendar seemed to emphasize a lot of pictures and images. A decision was made to complement this with more detailed captions and information provided within the calendar months.

When the second-grade team concluded their presentation, several suggestions were given about locations for fieldwork in nearby deciduous forests. One teacher made the suggestion of researching the feasibility of placing a mobile webcam within an area of the forest for later observation. Questions also surfaced involving the integration of other forms of math through problem-solving. This was specifically highlighted with regards to a new development that was cutting down deciduous forests for building purposes. Another suggestion was made regarding the possibility of authentic (community) service connected to forest conservation that second-graders could participate in.

After all three teams had completed the process, the cross-grade-level part of the meeting was underway. This part of the meeting yielded several themes across the three grade levels, including concerns and suggestions for improvements. One concern was brought up: all three expeditions had a strong focus on animals. The positive side of this—consistency—was evident; however, the drawback was the potential of missing out on non-living themes that primary students would benefit from. A decision was made that the positives outweighed the negatives, and it was agreed to structure the theme in a stair-stepping pattern vertically across grade levels. Kindergarten would focus primarily on Maryland, while the first grade would study the Monarch butterfly's migration patterns to Mexico. The second grade would be looking at a more global scale of deciduous forests and similar ecosystems in various parts of the world.

Another concern that was brought up during this part of the meeting was the fact that all three expeditions contained a significant amount of realistic drawing work as part of projects and the final product. Members of the meeting brainstormed different ways of yielding the same skill set, so students wouldn't be doing similar work three years in a row. A change was made to the first grade's expedition, replacing drawing with photography for the calendars. This change involved further discussion about bringing in an expert who would be able to teach a session on photography to the class. Ideas were brought up about how students could bring cameras to fieldwork so they could take photos of butterflies instead of drawing them. Likewise, changes were made in kindergarten. A decision was made to integrate more modeling and sculpture work for their final products. The kindergarten final product was therefore changed to a museum that would showcase the crab and osprey through 3-D sculptures.

More themes were uncovered during this section of the meeting, and there was a general level of enthusiasm from all participants (see Appendix I for the complete set of notes on this meeting). The teams were excited about how much more in-depth the expeditions had become this year, evolving from piloted versions in the previous year. They seemed to be very motivated to fine-tune ideas and add to as well as improve their expeditions. Everyone seemed happy to integrate cultural arts in a more authentic way. The music teacher had been tasked to teach personification of animals in music during the second-grade expedition. The art teacher had been assigned to make animal masks with the kids in second grade, as well as work with the kindergarteners to create sculptures of nests and eggs for the crab and osprey.

The observation during this section of the meeting revealed that many of the best ideas for expeditions had occurred cross-grade-level, where common themes had been identified and discussed, and decisions had been made for overall improvement. The researcher gained an understanding of the importance of this process of developing ideas through collaboration. This led to the realization that collaboration could be taken to a new level via an online community component in the curriculum mapping software, allowing the discussion to continue on an ongoing basis rather than being limited to the semi-annual meetings. In addition to this, the researcher developed a clearer understanding of some of the requirements of the system, such as the need to allow for different workflows, including modifying, changing, and republishing maps before and after peer review and collaboration. A roadmap for future functionality was conceived, which included an integrated scheduling tool and the ability to upload and share resources and lesson plans.

One week after the cross-grade-level meeting, the researcher observed a weekly grade-level team meeting with the second-grade team. Typically these team meetings are short and involve day-to-day planning and task assignment. In this situation, the purpose of the meeting was to further break down the approved expedition from the cross-curricular session into micro-level tasks and begin a process called *back-mapping*. Back-mapping involves a process of determining the skills and concepts that the students need in order to create the final product effectively and at a high level of quality. The process follows Wiggins and McTighe's backwards-design (UbD) framework, allowing the team to focus on outcomes-based learning.

The team meeting was structured into four main areas: an overview of the up-to-date state of the expedition, the current action points, the upcoming action points, and any concerns and modifications. During the overview, the final product was discussed, a decision was made on fieldwork visits for the semester, and three expert visitors that had been previously planned were confirmed. The current action points focused on fieldwork scheduling, the need for additional experts (based on changes from the cross-curricular meeting), and back-mapping the final product.

Observing this back-mapping process in action provided the researcher with valuable insight into capturing this information conceptually within a software-based system. It led to the realization that any business rules in the system must allow for the approach of *first* capturing skills and outcomes, and *later* completing the more detailed aspects of the map. It also gave the researcher the idea of including process documentation or a “guide for mapping” that would assist teachers. Full observation notes from the meeting have been included in Appendix J.

Teacher Involvement

During a curriculum mapping workshop coordinated by the researcher and the CMSC, teachers were handed a list of open-ended questions in order to solicit feedback, which would then serve as the basis for further discussion within smaller groups. In total, 18 teachers were surveyed. In addition to these questions, they were also asked to provide some basic demographic and web-usage information. A copy of the complete field survey used in this study has been provided in Appendix E.

An overwhelming number of the teachers who attended the event were female (72 percent), which realistically represented the actual population breakdown at the school. The majority of participants were also within the 18-29 age range, which again was an accurate representation of the Monarch staff. Two of the key questions asked, concerning web comfort and mobile access levels, revealed interesting results. These questions read as follows:

- What is your comfort level in using web applications? (e.g. Safari Montage)
- How often do you use a mobile device (iPhone, iPad, Android phone, Kindle, etc.) to access web applications?

The questions were scaled 1-5, with 1 meaning "least comfortable" and 5 meaning "most comfortable" using web applications, and with 1 meaning "not often" and 5 meaning "very often" accessing web applications on mobile devices. Regarding comfort in using web applications, over half of the respondents (61 percent) were either most comfortable (5) or one level below (4). No respondents indicated the "least comfortable" option (1), while 33 percent fell into the (2) and (3) ranges. Since the majority of the participant population contained younger teachers, the fact that they proved to be fairly comfortable with web technology is not that surprising. But when the participants were asked about how often they use mobile devices to access web applications, an overwhelming 83 percent indicated either do so "very often" (5) or one level below (4), with only 11 percent reporting less frequent use of mobile technology. (See Figure 13.)

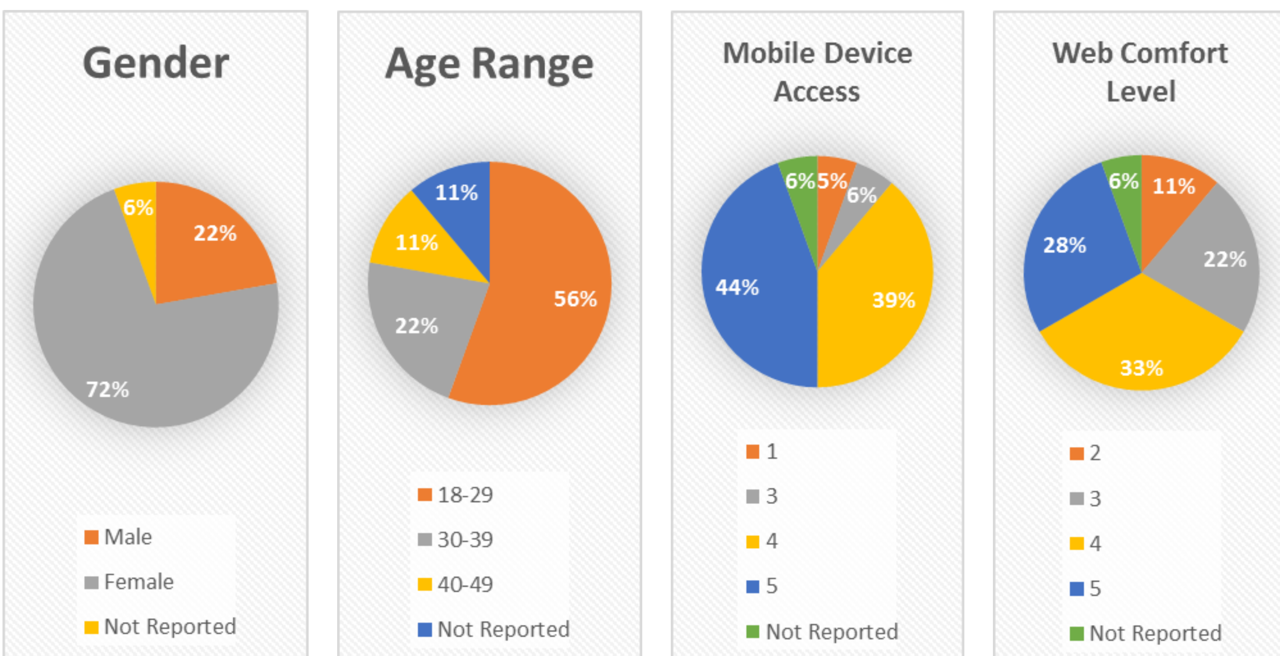


Figure 13 - Demographics, Mobile Access, and Web Comfort

It was clear that the majority of teachers within this population had a high level of familiarity with mobile device technology, while just over half were comfortable with traditional web applications. These results led to the realization that any software being designed for this demographic not only needs a high level of usability (to address comfort levels using web applications), but it should also be accessible using mobile technologies. Further insight into these issues was given within the responses to the open-ended questions. From these questions, several themes were identified and have been cataloged in Table 8.

Table 8 - Survey Themes

Obstacles	Physical Access	Process / Tools
Time	Tablet	ALA Common Core Crosswalk
Access & Availability	iPhone	Decisions on topic to teach
Document Management	School	Mapping to standards
Usability		AACPS Maps
Security/Updates		Develop LT & ST Targets
Stability		Summer CM and CC Alignment
		Grade team collaboration
		Alignment to Common Core
		Resources to meet/assess standards

Several obstacles were highlighted within both the results of the survey and the direct discussions with teachers. A recurring theme within the teaching environment is the challenge of **time vs. commitment**. As outlined in the literature review, teachers are routinely expected to work more hours than their allotted Monday-to-Friday time at school. This is also true for Monarch Academy teachers, who are already balancing multiple responsibilities in addition to their weekly teaching load. Time for curriculum mapping is therefore limited and has become a challenge to many. In order to accommodate this issue, any recommended curriculum mapping solution should provide a workflow that will be more efficient than current processes teachers must follow.

Another obstacle or challenge noted was the continual problem with **access and availability**. As mentioned earlier, most Monarch teachers are comfortable with the web and frequently use mobile apps. Unfortunately, some school applications require specific computer configurations for access. These include the presence of third-party software, such as Java and Adobe Flash. Quite often these plugins require updates and can cause other stability issues for the user's computer. Hence, **usability and stability** were related concerns that were raised regarding existing software applications. In addition to this, certain applications can only be accessed from the school premises, making it very difficult to complete common tasks (such as entering grades) when their hours at school are already packed full of commitments and obligations. It is therefore understandable that when asked where, ideally, they would like to physically access Monarch websites or web-based applications, a number of the teachers' responses indicated that they preferred access both within and outside of school. In addition to this, many indicated that their preference would be to access the application on their tablet or mobile device. Multiple access points therefore raised the question of **security**.

In addition to the obstacles and issues that arose in the survey, other tools and processes were revealed that had not been considered during the sprints. These included a number of resources (noted in Table 8) that the researcher had not encountered previously. It was apparent that these applications were used frequently by teachers during the process of expedition development. This affected several design decisions, including the need for easy access to resources and third-party applications that would assist the user during mapping. Analysis of this data shaped the planned functionality, such as allowing administrators to add and modify available resources in the various grade groups and permitting teachers to conveniently access the list of frequently used applications.

Another design decision that resulted from the data collected during the survey involved the process of data entry and in-built flexibility of the system to allow for a building-block approach to curriculum mapping. In other words, the final system should allow for an expedition building process that would enable the teacher to first define the topic and then determine which standards need to be met during the semester. The decision to define the final product before devising any lesson plans arises naturally out of the school's outcomes-based development using the UbD framework.

After results had been compiled from the surveys and the sixth sprint had concluded, the researcher conducted a set of usability tests with 11 teachers. The first test was considered a pilot and took place at the University of Baltimore's usability lab. Further tests were conducted remotely in order to better accommodate teachers' availability. The pilot revealed some flaws in the application itself, including a bug that prevented the authentication login functionality from working correctly within Internet Explorer. In addition to this, several layout artifacts, which were not anticipated in the prototype, appeared and hindered the test. It was also discovered that the questions presented in the pilot did not allow for enough depth and exploration during the test; therefore, several questions were rewritten for further tests. These ten remote usability tests were conducted over a period of four weeks. Each was recorded for further analysis and included time at the end of the test for additional open-ended questions.

The results of these tests were extremely positive. Most users found the system to be intuitive and easy to use. Several commented about how this system would save time for them in compiling and accessing curriculum mapping data in the future, compared with the current process of offline document management. There were, however, some challenges that users faced, which was evident across several testing sessions. These challenges have been listed in Table 9.

Table 9 - Usability Test Challenges

Challenge	Description
Interface/Buttons (coloring not always obvious)	Due to the grey coloring of the update, add, and cancel buttons, on several occasions the user missed clicking the button to complete their request.
General Workflow	The design of the main expedition form is very similar to that of the case study section. On several occasions users became disoriented as to where they were located in the application. While the breadcrumbs proved helpful, it seems that a better indication of where they were in the task process would have been best.
Dynamic Grids vs. Traditional Form Actions	While the grids updated immediately after the user selected add, update, or cancel, other elements of the form relied on the user clicking the save button at the bottom of the screen. On several occasions this was missed, resulting in unsaved/lost work.
Confusion with Controls	Certain drop-down select controls contained a lot of information. The science and social studies "big ideas" drop-down proved to be confusing to several participants, as each element wrapped into several lines.
Text-size in Facets	As with the "big ideas" drop-down select controls, several of the facet controls also caused similar confusion because of poor design.
Common Core Filtering	Common Core elements were available via a select box; however, because the list is extremely large, it would have been better served via a filtering option. Several participants found it difficult to locate specific Common Core standards.

Of all the issues discovered during the usability test sessions, the largest problem appeared to stem from the overall workflow. In several instances, it became apparent to the researcher that the user was unable to successfully navigate from task to task. Because of the similarity of the various data entry forms, coupled with no clear navigation or prompts on where to go next, quite often the user was unable to locate specific information or determine what to do next after a section was saved or completed. To rectify this, the researcher had to rethink some of the design elements of the system to provide a more cohesive experience.

In addition to these challenges, several suggestions were made during the question-and-answer session at the end of each test. Many of the participants requested functionality to create lesson plans for their curriculum maps. Discussion had taken place earlier, during the sprints, to limit the application to higher-level curriculum mapping and to exclude lesson-planning elements. The usability testing, however, highlighted how important this type of functionality may be to the teachers.

As discovered during the surveys, teachers use a range of external websites and applications during the curriculum planning process. Several participants in the usability tests suggested that it would be helpful for them to have a "resources" section, with links to the various sites and applications they require access to. Having everything in one place would increase the overall efficiency of their curriculum mapping process. Also, many of the participants commented on the usefulness of an "upload" feature, where they could attach different teaching resources to certain elements of the map.

Finally, almost all test participants confirmed that they would like to use the application remotely from home and via a number of mobile devices including iPads, Android tablets, and even phones. Future revisions to the application could be made, and later usability tests could focus on cross-platform and device access, uploading of files, and testing of newer workflow and web-component improvements.

Integration

The research activities carried out during the project served the purpose of contributing to the overall design of Expedition Mapper, validating decisions and serving as a way to gain a deeper understanding of the user community at Monarch Academy. The weekly sprints and prototype development activities proved to be the backbone of the research conducted, allowing for an iterative design process that led to the final application. The field surveys and observations served to give the researcher a deeper understanding of the inner workings of curriculum planning at the school and also provided insight into individual user needs. The usability tests were conducted towards the end of the study and caught other elements and design flaws that would otherwise have been missed. The usability tests also gave participants the opportunity to provide essential information for improving the system and, ultimately, their curriculum planning process. The researcher brought together these various elements of research and integrated them into the final application.

The Unified Theory of Acceptance and Use of Technology (UTAUT) provided a framework of elements that could ultimately lead to the user accepting or rejecting a technology. This model evolved from the popular Technology Acceptance Model (TAM), as detailed in more depth in Chapter 2. Performance expectancy, effort expectancy, social influence, and facilitating conditions are all important considerations, building upon the earlier TAM's perceived ease of use and perceived usefulness elements. The results from the field survey demonstrated areas that could be improved to enhance the various elements of the UTAUT. The researcher decided to focus on making the final application accessible on various devices by using responsive design techniques. A modern development framework was chosen to increase the level of both security and stability, while improving performance expectancy via a commercially proven database back-end. More details of the technical specifications are covered in Chapter 5.

Usability testing revealed that most participants were positive regarding overall effort expectancy. Outside the challenges that were previously documented, most participants found the experience to be more efficient than their current workflow. A reoccurring theme throughout this research has been consideration for teachers' time and commitment to new technologies and processes. By providing a solution that will not only lessen the time needed to accomplish tasks, but also provide additional benefits, such as immediate access to other maps, resources, and external applications, teachers will be more likely to adopt and also to influence their peers in a positive manner.

The observations carried out by the researcher provided information needed to make improvements on the design of the application. The meetings that were observed highlighted the fact that any online or web-based solution should incorporate a mechanism to encourage cross-grade-level collaboration. While such a mechanism would not be made available in the first version of the application, future versions could include an online community component, where teachers could be consistently connected during the semester, instead of only at the curriculum planning meetings. (One of the criticisms of Jacobs was that semiannual curriculum planning meetings are not conducive to effective curriculum planning. This was covered in greater detail in Chapter 2.) By providing an online component for collaboration throughout the school year, in addition to the scheduled cross-curricular meetings, administrators and teachers will have greater flexibility to enact changes and improvements more quickly and efficiently. The meeting observations also demonstrated that there should be an easier way for grade-level teams to review the current state of each other's curriculum maps and to provide feedback where applicable. Access to past years' maps and pilots is also part of the overall curriculum mapping process at Monarch Academy and should be integrated into the application.

Finally, only so much can be done to make the final application more useful and usable. In order to fully take into consideration the various elements of acceptance and to ensure that teachers will be able to use any implemented solution to its full potential, a comprehensive training and implementation plan should be developed prior to launching the application. Training sessions would also provide the opportunity to further "sell" or bring on board those teachers or users who may be skeptical about a new process. The research carried out here led to the development of an alpha build of the Expedition Mapper application; however, this will need to be further developed before an actual launch at the school. Details of the application and its technical specifications are provided in the next chapter.

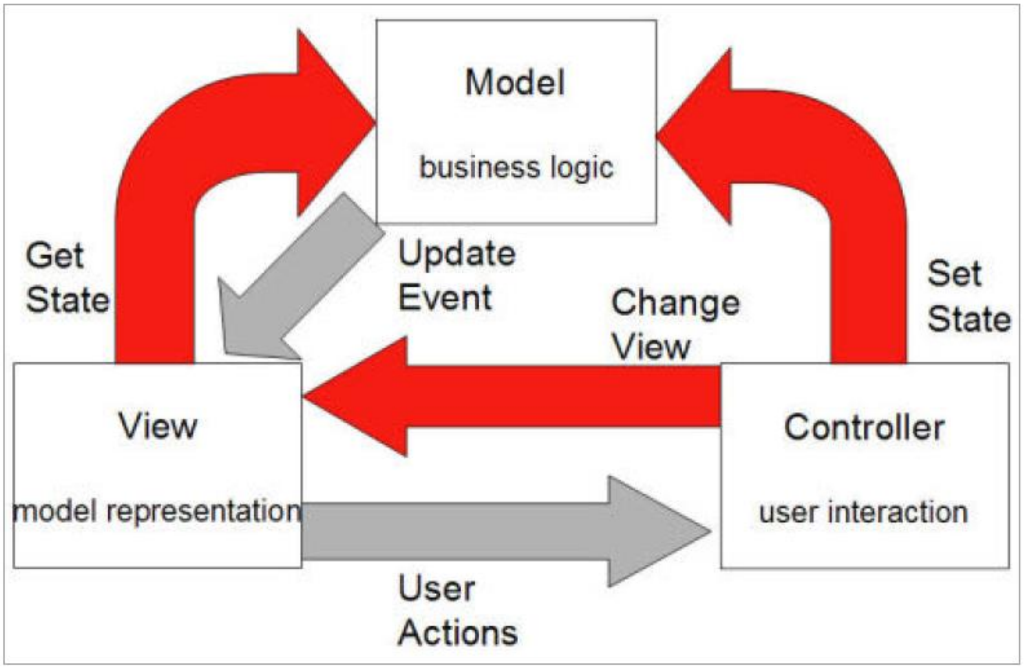
Chapter 5: Technical Architecture

At the conclusion of this study, an alpha build of Expedition Mapper was completed. This build included much of the code from the interactive prototype, with additional changes and enhancements influenced by the research activities and usability testing sessions. This chapter details the technical architecture of Expedition Mapper. The application is scheduled to be rolled out into Monarch Academy for the 2014-2015 school year, and continual enhancements and changes will be applied to future builds. For the scope of this project, it was not possible to build a feature-complete reporting and administrative module. Most of the infrastructure written for the alpha build focused on user interactions at the teacher level for entering expedition and semester-based data.

Architectural Platform

The researcher chose to develop Expedition Mapper using the Microsoft ASP.NET development framework. ASP.NET is a development framework for building web pages and websites with HTML, CSS, JavaScript, and server scripting. It was first released in January 2002 with version 1.0 of the .NET Framework, and it is the successor to Microsoft's Active Server Pages (ASP) technology. The framework supports three different development models: Web Pages, Web Forms, and MVC (Model-View-Controller). The Web Pages model is typically used for the design and development of small applications or for rapid application development of interactive prototypes. It is the simplest ASP.NET model and is similar to the PHP programming language and classic ASP (an earlier Microsoft development language). The Web Pages model comes with built-in templates and helpers for database, video, graphics, and social media integration. Web Forms is the traditional ASP.NET model, which has been used for many years to build web applications using a choice of drag-and-drop form controls or written code. It is an event-driven platform and provides a toolset for optimized web server events and code. In recent years, the Model-View-Controller (MVC) architectural pattern has become the preferred choice for enterprise-level applications within a variety of web application development languages.

The MVC pattern was introduced by Trygve Reenskaug at Xerox Parc in 1976 and is documented in his article "The Original MVC Reports" (1979). MVC separates web applications into different components and provides a lighter-weight framework. The approach concentrates on separation of concerns and the DRY (Do Not Repeat Yourself) best practices of programming. The DRY principle aims to avoiding repetition of any part of a system by abstracting out things that are common and placing those things in a single location. This principle is not only concerned with code but any logic that is duplicated in a system; in other words, there should only ever be one representation for every piece of knowledge in a system (Millet, 2010). Separation of Concerns, often abbreviated as SoC, is a method of software development where the application logic is separated from the interface design, allowing for better maintainability, scalability, and accessibility by different devices. The authors of a 2005 article in *Personal & Ubiquitous Computing* demonstrated how the MVC pattern could be used to support different devices by implementing a separate view state or user interface for each (Sauter, Vögler, Specht, & Flor). Microsoft introduced MVC as one of the ASP.NET development models in 2009. MVC has a steeper learning curve than the other models; however, it also allows for more advanced programming techniques to support scalability of larger systems.



(Earley, 2013)

Figure 9 - Model-View-Controller Architectural Pattern

The diagram in Figure 15 demonstrates how the MVC pattern works. First of all, the controller receives a user action from the view; in turn, it decides what needs to happen next. Depending on the current state of the application, the controller will either change the view or set the state of a model. An example of this could be a simple data entry form. The user enters the details and then presses the submit button. The controller sends this to the model, which is a representation of the business logic, database tables, or fields. If it is a valid entry and passes the business rules (or validation), the records are updated (or the state is changed), and confirmation is sent to the user in a new or updated view. If validation is not met, the controller sends the view back to the user, who will then be prompted to enter the correct data.

The familiarity of the researcher with both ASP.NET and the MVC approach to development factored into the choice to use this platform. There are many other viable development platforms, both commercially and freely available. The maturity of ASP.NET, its reputation for being a highly secure programming platform, and its community development support also played a major part in the decision to use this technology. In his article on the modernization of IBM i applications, Earley (2013) discussed the benefits of using the Model View Controller architecture pattern, including support for better application scalability, web services, and most importantly, efficiency of application maintenance. Earley also discussed the importance of *application modernization*, a term that is often used to describe a process or model of software development aimed at supporting multiple systems and devices. Earley defined three purposes of the application modernization process: to ensure existing applications remain in place, unchanged and functional; to implement new interfaces for existing data structures and applications; and to ensure that new interfaces provide access to additional programming languages and application services that subsequently provide access to additional devices.

Other research demonstrates a correlation between using an MVC pattern and benefits for usability in general. In his thesis, Aihara (2009) carried out a study to determine the usability benefits of developing software using MVC. In his study, he developed two prototypes, one built with MVC and the other with a traditional object-oriented framework. His findings revealed that the MVC framework provided benefits in several areas, including form validation, consistency, and multiple views (for multiple devices).

In the findings presented in Chapter 4, it was clear that the teachers' preferred choice for accessing web applications varied over a number of different devices. Application modernization through the MVC architectural pattern was therefore the preferred choice for developing a solution that would cater to these needs.

Design Patterns

Expedition Mapper was developed in the Microsoft ASP.NET framework using the C# object-oriented programming language. The first object-oriented languages came into existence during the 1960s and 1970s with Simula and Smalltalk (Pefkaros, 2008). The object-oriented programming paradigm was created partly to deal with the ever-increasing complexity of software systems (Hadar & Leron, 2008). However, in their article titled, "How Intuitive is Object-Oriented Design," Hadar and Leron made the point that as software has become more sophisticated, the process for learning object-oriented design has become much more complex. Thanks to modern programming languages and frameworks such as Microsoft ASP.NET, coupled with C# and architectural patterns, development has become less complex; however, it still requires a broad understanding of object-oriented principles.

Object-oriented programming takes real-life concepts and maps them as objects and classes. The real advantages of object-oriented development lie in its inherent benefits of code reuse and scalability. As mentioned earlier, object-oriented programming can become complex in larger, sophisticated systems. Often it can be a challenge for a software developer to understand how to structure the architecture of a system. Architectural patterns such as MVC help with this process; however, even these types of patterns are broad and leave many of the details to the developer.

Over time, the proponents of software development have evolved myriad "best practices" to ameliorate the design process (Mangalaraj, Nerur, Mahapatra, & Price, 2014). One of the more commonly used best practices includes design patterns. To assist with development, programmers often lean on these design patterns in order to architect their systems. Like architectural patterns, design patterns are reusable solutions to common problems in software design. While an architectural pattern, such as MVC, is a broad pattern used for development, design patterns tend to be slightly more specific to functions within a system. They are essentially templates or code solutions, which developers can use within their applications, that have already been proven to be very powerful in designing complex systems.

The idea of design patterns originated with Christopher Alexander, a British/Australian architect (Pieters, 2010). Alexander was responsible for designing more than 200 buildings worldwide throughout Europe, Southeast Asia, and Japan. In 1977, Alexander released a book entitled *Towns, Buildings, Construction* in which he proposed different patterns for architectural design that could be recognized and reused. His book contained design patterns for constructing various parts of buildings.

The idea of using design patterns in software resonated with developers in the 1980s. Some of the early pattern work, mostly concerning human interface patterns, was done by Ward Cunningham and Kent Beck in 1987. Several years later, more discussions at conferences, such as OOPSLA (Object-Oriented Programming, Systems, Languages & Applications), were held with individuals such as Erich Gamma and Richard Helm (Larsen, 1999). One of the most seminal works on software development with design patterns was written by the Gang of Four—Erich Gamma, Richard Helm, Ralph Johnson, and John Vlissides—titled *Design Patterns: Elements of Reusable Object-Oriented Software*. This was the first software design patterns book to come to press; it was released in 1994. This book was considered to be the definitive set of software design patterns at its time of writing and brought in many of the formal design patterns used in software development today.

The Gang of Four (GoF) documented 26 design patterns, placed under 3 categories: creational, structural, and behavioral patterns. Creational patterns concern the process of object creation. Structural patterns deal with the composition of classes or objects. Behavioral patterns characterize the way in which classes or objects interact and distribute responsibility (Gamma et al., 1994). Since this initial publication, many other design patterns have emerged under many more categories, and the design pattern library has continued to grow as the software development craft has matured. In 2010, Scott Millett released the first comprehensive publication aimed at design patterns for ASP.NET. In his book, he documented many of the GoF design patterns, along with more recent additions applicable to the ASP.NET development framework. Millett also provided code samples and an entire Visual Studio sample project for ASP.NET, which used all of the patterns documented in his book.

While the detail of each design pattern goes beyond the scope of this study, it is important to understand the significance and importance of design patterns in general. A list of the GoF patterns is offered in Appendix K. Design patterns bring many benefits to the field of software development. Perhaps the most important benefit is the common or shared language it brings to the profession. Knowledge of the various design patterns and how they can benefit a project ensures that a developer can avoid "reinventing the wheel" when it comes to a particular functionality or process. Design patterns can also provide a strong starting point for a solution, can speed up production time, and can ultimately improve overall system and application design. Expedition Mapper was built with several design patterns for a process known as Object Relational Mapping, which is covered in greater depth later in this chapter. The Unit of Work and Query Object patterns were implemented in the alpha build of the application. The Repository pattern was also implemented to allow for better scalability.

Millet (2010) describes the Unit of Work pattern as a design for maintaining a list of business objects that have been changed by a business transaction, whether that be adding, removing, or updating. The Unit of Work then coordinates the persistence of the changes as one atomic action. If there are problems, the entire transaction rolls back. What this essentially means is that during the process of managing different transactions, the system maintains a record of any changes that will need to be applied (or persisted) to the database. Once a SaveChanges command is executed, the system then gathers up all of the transactions and sends them to the database as one set of commands, or in the case of a relational database, a SQL (Structured Query Language) query. The Query Object pattern is derived from the GoF Interpreter pattern. It essentially provides a way to write object-oriented code to interact with a dataset, such as a relational database, which can later be converted to a database language such as SQL.

ASP.NET MVC comes with many libraries already built in to allow for easy implementation and use of various design patterns. Expedition Mapper uses the database context library from ASP.NET MVC to provide a class for describing database objects and for applying the Unit of Work pattern. An additional language called Linq has been used to provide an easy way to implement the Query Object pattern.

Object Relational Mapping

Object Relational Mapping is the process of translating object-oriented data or object model data to a database (relation) model. It provides the internal mechanism for converting code within an object-oriented system into SQL queries and commands the database can understand. In order to understand why these two data models exist, as well as the need for translating between them, we need to first look at their individual goals. The goal of object modeling is to model a business process by creating real-world objects with data and behavior. It describes systems as a collection of objects, describing their current state as well as possible behaviors. Relational modeling, on the other hand, is concerned with eliminating redundant data from tables. It describes data in term of tuples and relationships. Its purpose is to provide a declarative method for specifying data and queries (Prabhu, 2013).

There have been many Object Relational Mapping (ORM) products in recent years that developers have been able to use within object-oriented programming languages. The more common ORM systems for ASP.NET have included NHibernate and Entity Framework. NHibernate is an open-source project based on the well-known Java-based ORM, Hibernate. In earlier releases of MVC, this was the preferred choice of ORM for many developers. NHibernate involved a substantial learning curve, and developers had to write mappings in XML (eXtensive Markup Language) for every object and property. As the ASP.NET MVC platform matured, Microsoft developed and released its own ORM called Entity Framework. The purpose of Entity Framework was to provide an integrated experience for the ASP.NET developer. It involved a less significant learning curve to work with and has quickly become a popular alternative to NHibernate for many developers. Expedition Mapper uses the Entity Framework 6 ORM for persisting data. The solution consists of the three main projects listed in Table 10.

Table 10 - Expedition Mapper Project Structure

ExpeditionMapper.BE	The Business Entities (BE) project contains definitions of all objects used in the system. This is where future business logic and validation could be integrated easily.
ExpeditionMapper.DAL	The Data Access Layer (DAL) contains the Entity Framework context library and repositories for persisting data to the relational database.
ExpeditionMapper.UI	The User Interface (UI) layer contains the MVC structure for the responsive web system, which collaborates with the other layer via dependency injection.

The context, or DbContext as it is named within Entity Framework, is the lowest level subset of the ORM process. It describes the various objects within the system, which are derived from their definitions in the Business Entities project. The code listed below (Figure 15) contains the context definition for Expedition Mapper.

```
namespace ExpeditionMapper.DAL.Provider
{
    public class ExpeditionContext : DbContext
    {
        public DbSet<Expedition> Expeditions { get; set; }
        public DbSet<CaseStudy> CaseStudies { get; set; }
        public DbSet<GuidingQuestion> GuidingQuestions { get; set; }
        public DbSet<GradeLevel> GradeLevels { get; set; }
        public DbSet<ExpeditionHabit> ExpeditionHabits { get; set; }
        public DbSet<ScienceBigIdea> ScienceBigIdeases { get; set; }
        public DbSet<SocialStudiesBigIdea> SocialStudiesBigIdeas { get; set; }
        public DbSet<Fieldwork> Fieldworks { get; set; }
        public DbSet<Expert> Experts { get; set; }
        public DbSet<ServiceLearning> ServiceLearnings { get; set; }
        public DbSet<StaCollection> StaCollections { get; set; }
        public DbSet<Standard> Standards { get; set; }
        public DbSet<LongTermTarget> LongTermTargets { get; set; }
        public DbSet<ShortTermTarget> ShortTermTargets { get; set; }
        public DbSet<Assessment> Assessments { get; set; }
        public DbSet<StaGrid> StaGrid { get; set; }
    }
}
```

Figure 15 - Expedition Mapper Context

The context describes sixteen objects, which are defined in the BE project. Each of these objects corresponds with a database table. Starting at the beginning of the code, we see a namespace called ExpeditionMapper.DAL.Provider. It is good practice to use namespaces with descriptive characteristics. This namespace tells us we are in the DAL project within the Provider section. The DAL project consists of a series of other sections, including repositories, interfaces, and references to other ASP.NET libraries. The class itself is called ExpeditionContext and inherits from DbContext. *Inheritance* is an object-oriented programming concept whereby a set of functionality can be applied to another class or component of the system. Each of the sixteen objects described in the class includes a Dbset command that describes the corresponding database table. In the code, the object Expedition has been mapped to the corresponding Expeditions table within the database. Likewise the CaseStudy object has been mapped to the CaseStudies table, and so forth. The get and set statements, often referred to as getters and setters, control whether or not a property is read-only. Setters can also be used to inject other logic or data into the property. In order to understand how the individual objects are defined, the Expedition object code is referenced below (Figure 16).

```
namespace ExpeditionMapper.BE.Domain
{
    public class Expedition
    {
        public int Id { get; set; }
        public int Year { get; set; }
        public int GradeLevelId { get; set; }
        public string Name { get; set; }
        public string Description { get; set; }
        public string KickOff { get; set; }
        public string FinalProductName { get; set; }
        public string FinalProductDescription { get; set; }

        [ForeignKey("GradeLevelId")]
        public virtual GradeLevel GradeLevel { get; set; }

        public virtual ICollection<CaseStudy> CaseStudies { get; set; }
        public virtual ICollection<GuidingQuestion> GuidingQuestions { get; set; }
        public virtual ICollection<ExpeditionHabit> ExpeditionHabits { get; set; }
        public virtual ICollection<ScienceBigIdea> ScienceBigIdeas { get; set; }
        public virtual ICollection<SocialStudiesBigIdea> SocialStudiesBigIdeas { get;
set; }
    }
}
```

Figure 16 - Expedition Mapper Object Definition

The Expedition class describes the properties of the Expedition object. The first eight properties, from ID to FinalProductDescription, are a representation of the database table columns. Attributes can be used to define foreign key relationships, and navigation properties (shown at the bottom as virtual) describe one to many relationships with other objects. To see a visual representation of how this data structure is defined in the database, refer to Appendix D.

As mentioned earlier, Expedition Mapper implements the Repository design pattern. The system uses two main repositories named ExpeditionRepository and CaseStudyRepository. The purpose of the repositories is to handle system requests to retrieve, update, or delete data within object properties. When a repository has carried out all of its transactions, the SaveChanges method of Entity Framework is called to persist all updates directly to the database. At this point SQL scripts are generated and sent to the relational database to process. The SaveChanges method employs the Unit of Work design pattern, whereby all changes are committed together in one transaction to the database.

The processes described, including object relational mapping and the various design patterns used, have only been touched upon at a high level. There is a considerable amount literature on these topics, and it is constantly changing as the profession of software development continues to mature. At the time of writing, however, Expedition Mapper integrated the latest versions of Entity Framework and ASP.NET MVC.

Interface Design

It became clear from the many interactions with teachers at Monarch Academy that they used a number of different platforms, ranging from traditional PC and Mac setups to iPhone, iPad, and Android mobile devices. One option to cater to these various needs would be to develop specific front-end mobile applications for each device, which would be driven by the back-end ASP.NET application. This would give users of each device the opportunity to download and install a native version of Expedition Mapper. This type of development, however, can be quite costly, as developing native applications for each platform would require a much longer development time.

In recent years, developers have gotten around this problem by writing software that responds well to different devices and screen sizes. This type of development or design strategy is referred to as *responsive design*. Responsive design was conceived as recently as 2010, but adoption is growing rapidly because it offers a more scalable solution for designers, allowing them to move away from designing different websites for every platform, and instead designing sites that scale differently in different contexts (Rempel & Bridges, 2013). Expedition Mapper was built using a responsive framework called Bootstrap. Previously called Twitter Bootstrap, Bootstrap 3 is a responsive framework originally conceived by the Twitter development team. It was originally based on the famous 960 grid, which was a CSS framework that allowed for easy layout using a 12-column grid system at 960 pixels wide. Bootstrap, in contrast, uses varying widths to allow for its responsive capabilities.

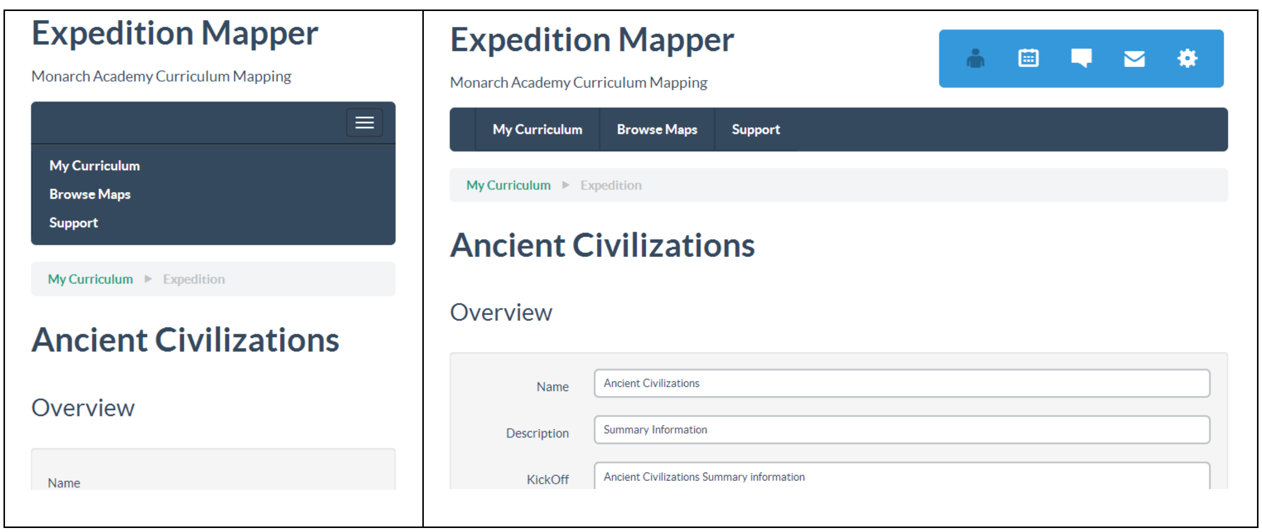


Figure 17 - Expedition Mapper Mobile and Desktop Responsive Views

The screenshots in Figure 17 demonstrate the basics of responsive design within Expedition Mapper. On the left-hand side, we see the mobile layout, which uses a narrow screen. On the right-hand side is the desktop or tablet view. Responsive elements of the layout change depending on the context. One example of this can be seen in the screenshots, where a mobile menu is rendered in place of the horizontal navigation for desktop/tablet use.

A flat design was selected for Expedition Mapper to ensure that the interface was clear and easily accessible on any device. In the earlier days of mobile device application design, beautifully shaded user interfaces with gradients and rounded corners were the norm. In contrast, a flat design eliminates drop shadows, gradients, and other attempts to create a sense of three-dimensional physicality. Many are now turning to flat design as a more practical option for their websites and mobile platforms (Bram, 2013).

The user interface for Expedition Mapper was developed from the research gathered in this study. The researcher took into consideration the problems and issues that the teaching community at Monarch Academy had previously experienced with other systems, aiming to avoid such annoyances. During the field survey, one of the recurring themes of importance to end-users was usability or the user experience. Earlier mockups of wireframes and prototypes were developed into an easier-to-manage workflow that used advanced interactions within dynamic grids. In order to develop these interactions within Expedition Mapper, a JavaScript framework called Kendo UI was used to compliment Bootstrap and bring additional functionality for advanced interactions.

Kendo UI is a development framework that utilizes JavaScript and HTML5 to provide rich user interactions. Expedition Mapper uses the Kendo UI grid system, which enables the display of dynamic data and the ability to easily update, delete, and add records without the need for traditional web form submissions. The screenshot below (Figure 18) illustrates a Kendo UI grid within Expedition Mapper.

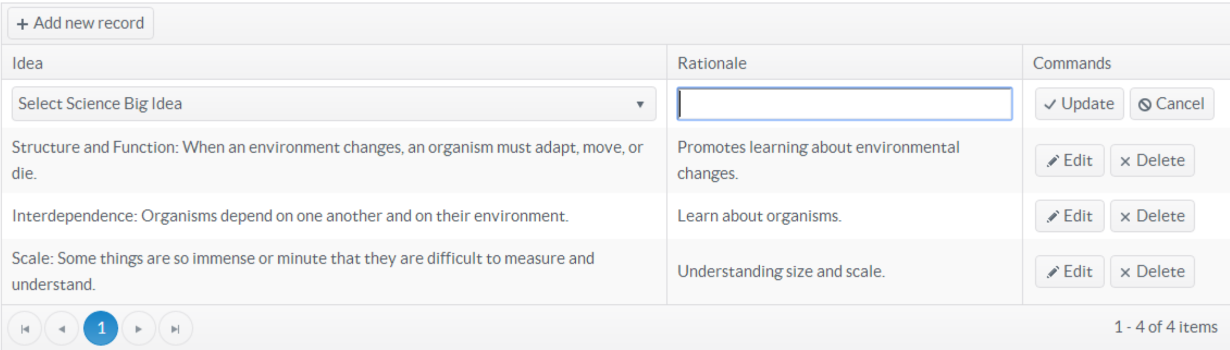


Figure 18 - Kendo UI Grid

Kendo UI is a commercial suite of tools developed by Telerik. It is a modern framework that embraces the advances of HTML5, CSS, and JavaScript. It provides a set of tools to enable rich web development and configurable widgets, all with a familiar syntax (Adams, 2013). There are also other JavaScript framework alternatives, including the commonly used jQuery UI and jQuery Mobile. The researcher chose Kendo UI because of its support and components built specifically for ASP.NET MVC. In addition to this, Kendo UI is an ideal platform for developing hybrid applications and mobile-compatible websites (Nair, 2013).

During the usability testing sessions, several issues were highlighted that prompted the researcher to make some adjustments to the overall interface design of the application. A newer mockup of how the system would look in future builds was created to provide a more integrated experience. The newer design incorporates a dashboard look and feel, along with other interface enhancements. It provides easier access to sections within an expedition to improve overall workflow for the application. The design also provides for notifications, alerts, and news items that may be posted by the administration team for semester-opening events, deadlines, etc. In addition to this, a global search has been added to improve the findability of items and resources within the system. The newer design is shown below (Figure 19).

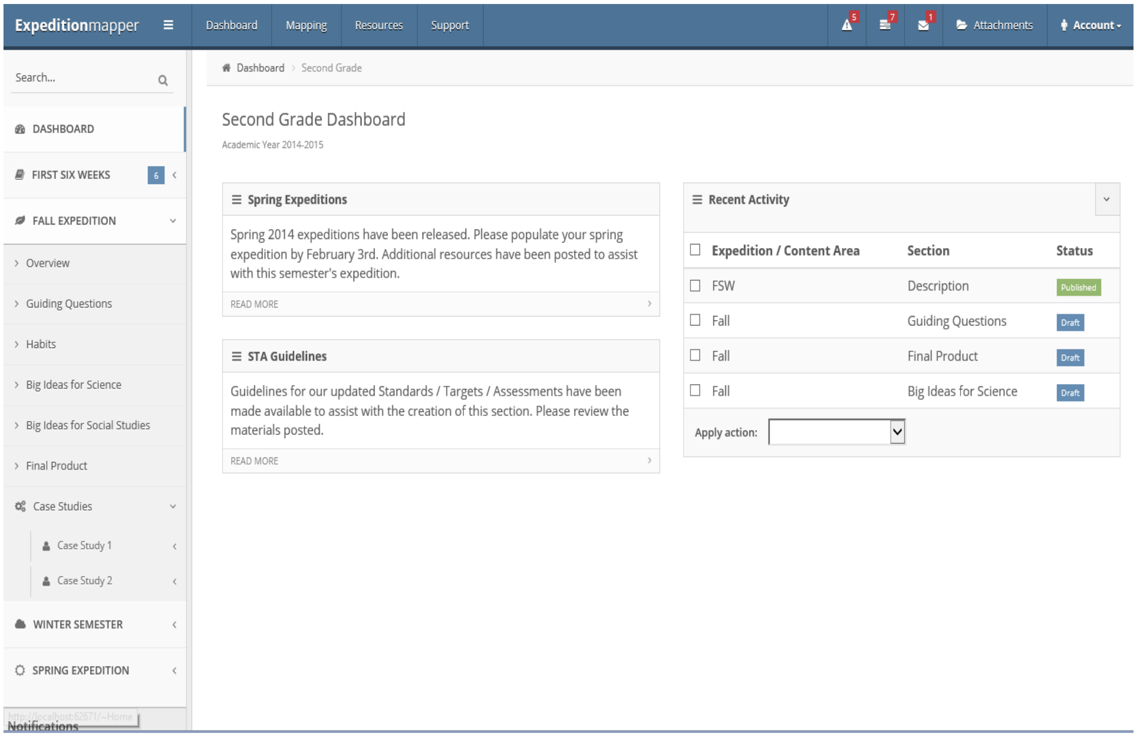


Figure 19 - Interface Enhancements

Summary

This chapter served as an overview of the technical architecture of the alpha version of Expedition Mapper created during this study. This version of the application was the result of the researcher's evaluation of EL curriculum mapping needs, discovered through various research activities carried out at Monarch Academy. As new versions are created and the system is further refined, other changes are anticipated. With the flexibility of the underlying technology used to build this application, along with the coding conventions, architectural platform, and design patterns implemented, future changes will be incorporated relatively easily.

Chapter 6: Conclusion

The research carried out in this study sought to understand the unique curriculum standardization needs and requirements of Monarch Academy's administration team and teachers. In April of 2013, an initial kick-off meeting was held with the administration team and a select group of teachers from Monarch Academy. Since that time, a process of user-centered research and an Agile software methodology has led to the creation of an Expeditionary Learning curriculum mapping solution as well as a roadmap for further development.

The process of defining and further understanding the challenges and problems Monarch Academy faced involved a deeper understanding of several areas of research. These included curriculum mapping, Expeditionary Learning, and the curriculum planning processes. The literature review presented in Chapter 2 provided the researcher with a broad understanding of these topics, and a review of several adoption theories led to a better understanding of factors influencing technology acceptance. It was important to understand how teachers perceived their current curriculum mapping practices and how any proposed solution would lead to long-term user acceptance. Working directly with Monarch Academy allowed the researcher to address the distinctive challenges of EL, while adhering to user-centered design principles. The Agile approach led to a better understanding of the specific challenges facing the school, enabling the developer to work directly with teachers and administrators to build the best solution to their problem.

One of the underlying reasons for Monarch Academy's initiative to integrate curriculum mapping was to achieve alignment with Common Core, which is mandated by the state. As

Common Core continues to evolve, a stronger emphasis on mapping curriculum with standards will continue to increase in importance for schools. Mapping initiatives to identify instructional gaps, both vertically across grades and horizontally within grade levels, and to align instruction with outcomes-driven design or backwards-design methodologies will continue to aid schools in strengthening their curriculum planning.

In the case of Monarch Academy, simply providing a software application or toolset for curriculum mapping was not enough. Attention needed to be placed on actual processes within the school. By working directly with a team from the school, the researcher was able to collaborate and devise a solution that not only fit with current processes, but also influenced a new framework for the school to build on. The technologies that were chosen for building this application are conducive to change and scalability. The team at Monarch recognizes that the process of curriculum mapping is constantly evolving; therefore, any software or tool used to aid this process needs to be flexible for future change.

Limitations

There were various limitations to this study, which has left some areas of research open for future studies. First and foremost, access to the population pool of teachers was challenging throughout the study. At the time of the study, there were approximately 40 teachers who worked at Monarch Academy. Of this population, only 21 were able to participate in the field survey conducted at a professional development session in December 2013. The maximum number of teachers the researcher was able to recruit for usability testing was 11 (1 for a pilot test and 10 for remote testing). The limited numbers shaped the study, which leaned on a more qualitative approach. Had the number of participants been larger, a more quantitative approach could have been carried out using eye-tracking technology at the University of Baltimore labs. In addition to this, due to the limited population pool, screening was virtually non-existent.

Due to the nature of this study, which was focused on Expeditionary Learning within a specific school, it could be argued that the generalizability of this research may be limited. While the research activities carried out throughout the study were aimed at specific needs, much of the research in terms of process and framework could still be applied within other settings or schools, especially other schools that use EL. The final application built from this research study is very specific to Monarch Academy; however, the framework used to develop this platform could theoretically be adapted for a number of other schools and educational models.

Another limitation that the researcher had to work with was the overall timeframe allocated to this study. Only so much could be developed in terms of a fully-fledged application, as it was being developed alongside various research activities. For this reason, the researcher developed a road map of features, detailed in Appendix L. This roadmap enabled the researcher to plan for and deploy a certain feature set with the alpha release of the application, while also planning for further feature integration in the beta, version 1, and version 2 releases of the software.

Research Contribution

The contribution this research study provided was the alpha version of an EL curriculum mapping software solution, along with the analysis developed from the Agile process and user-centered research activities. The development name *Expedition Mapper* was chosen early in the project for labeling the application. To complement this, the website ExpeditionMapper.com was created as a communication and documentation portal while both the development and research activities were carried out. The final alpha build of Expedition Mapper contained three projects: the user interface, data access, and business entities/logic of the application. The user interface project was built using Microsoft's MVC 5 framework, which allowed for greater code separation to support future changes and scalability. The data access project implemented Microsoft's Entity Framework Object Relational Mapper (ORM) for data persistence. The business entity/logic project included C# domain objects describing database tables and columns, which would later be mapped to SQL Server. The application contained over 1300 lines of code, excluding the SQL Server constructs including tables and views. More details about the technical architecture of Expedition Mapper are provided in Chapter 5.

The initial alpha version of the software contained a limited feature set, with the goal of further development during the summer of 2014 in order to have a feature-compete Version 1 ready for Monarch Academy's fall semester. The matrix in Table 11 highlights top-level features within the alpha and beta builds, as well as the roadmap features for version 1 and future releases. A more detailed roadmap of features is provided in Appendix L.

Table 11 - Expedition Mapper Feature Matrix

	Alpha & Beta Releases	Version 1.0	Future Releases
Complete Data Entry Forms	X		
Complete Reporting and Mapping		X	
Roles Implementation		X	
Administration Panel		X	
User Account Authentication	X		
Custom Field Generation		X	
Business Logic / Validation	X		
Multiple Device Compatibility (Mobile)	X		
Import Prior Years data / Expeditions		X	
Integrated Calendar			X
Advanced Charting			X
Integration with other Educational Models			X

Data entry components were finalized prior to completion of the alpha build, and these provided the functionality needed for the various usability testing sessions. This build also included partially completed reporting, full user authentication, and account management, business logic, and a complete responsive design for multiple device accessibility. The final Version 1 build, planned for fall 2014, will include completed mapping and reporting functionality and roles implementation for various teacher roles and non-grade-level teachers. A feature-complete administrative area is planned for Version 1, along with custom field generation, which would support future changes to the curriculum mapping framework. Finally, an expedition import feature is planned before the 2014 rollout. Future release plans include calendar integration, advanced graphical reporting, and possible integration with other education models.

Further Research

The research that took place during this project involved user-centered and Agile methodologies. During this process, other elements of research supported some of the decisions made in the final design of the application. One these areas involved an earlier analysis of the Technology Acceptance Model (TAM) and subsequent models including the Unified Theory of Acceptance and Use of Technology (UTAUT). Further research in the area of adoption or acceptance could be carried out in a separate study by using one of these models and developing an appropriate methodology with specific acceptance surveys or other research instruments. This would ideally be done within schools or school systems where the researcher would have access to a larger population pool of participant teachers to provide rigor via a quantitative study.

Another area for research that could be considered is the feasibility of modifying Expedition Mapper to be compatible with other educational models. One of the early challenges

Monarch Academy faced was the fact that their educational approach (Expeditionary Learning) did not fit into the standard units and subjects mapping framework that many other schools implement. There are other educational approaches besides EL that vary from the "norm" and which also have unique curriculum mapping concerns and needs. Models such as International Baccalaureate, which is an approach being introduced in a new Monarch school in 2014, also have special requirements in terms of curriculum mapping. Montessori is another example of a non-traditional educational approach; although schools that follow this model tend to be private in nature and do not have to adhere to Common Core, curriculum mapping would still benefit their unique approach. Further research would be needed in order to determine what would be required to adapt Expedition Mapper to one of these other models.

Expedition Mapper was written to serve a very specific purpose, but at the same time it was built to be flexible and conducive to changes within the school or schools it serves. Future plans for this application include potential integration with other EL schools and possibly, if successful, other educational institutions that rely on non-standard educational approaches. More work is needed; however, this research serves as a framework for analysis, development, and implementation of a curriculum mapping solution for a non-traditional K-6 institution.

Appendices

Appendix A: Research Activities Timeline

Project Initiation	
Curriculum Mapping Kickoff Meeting	April 10, 2013
Agile Sprint Meetings	
Sprint 1: High Level Requirements (Prototype 1)	September 3, 2013
Sprint 2: Defining Expectations (Prototype 2)	October 10, 2013
Sprint 3: FSW and Winter Terms (Prototype 3)	October 17, 2013
Sprint 4: Non-Expedition Subject Areas	October 30, 2013
Sprint 5: Data Elements Review and Reporting	November 6, 2013
Sprint 6: Application Demo and Reporting	December 19, 2013
Prototypes	
Axure Prototype 1	July 10, 2013
Axure Prototype 2	September 18, 2013
Axure Prototype 3	October 10, 2013
Axure Prototype 4	October 24, 2013
Axure Prototype 5	November 4, 2013
Axure Prototype 6	November 8, 2013
ASP.NET Prototype	December 11, 2013
Field Survey	
Curriculum Mapping	
Professional Development Session	December 17, 2013

Observations

Cross-Curricular Meeting	January 8, 2014
Grade Level Team Meeting (2nd Grade)	January 15, 2014

User Testing

Session 1	December 17, 2013
Session 2	December 20, 2013
Session 3	January 11, 2014
Session 4	January 14, 2014
Session 5	January 15, 2014
Session 6	January 15, 2014
Session 7	March 3, 2014
Session 8	March 9, 2014
Session 9	March 9, 2014
Session 10	March 16, 2014

Appendix B: IRB Approval

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September 11, 2013

Ian Carnaghan
1502 Silverbirch Lane
Laurel, MD 20708

Dear Mr. Carnaghan:

This letter serves as official confirmation of the Institutional Review Board's review of your protocol for a study entitled "An Expeditionary Learning approach to effective curriculum mapping," submitted for review on August 22, 2013.

The Institutional Review Board considered your request and concluded that your protocol poses no more than minimal risk to participants. In addition, research involving the use of widely acceptable survey/interview procedures where the results are kept confidential and the questions pose minimal discomfort to participants is exempt from IRB full-committee review per 45 CFR 46.101 (b) (2). As a result, the Institutional Review Board has designated your proposal as exempt.

Investigators are responsible for reporting in writing to the IRB any changes to the human subject research protocol, measures, or in the informed consent documents. This includes changes to the research design or procedures that could introduce new or increased risks to human subjects and thereby change the nature of the research. In addition, you must report any adverse events or unanticipated problems to the IRB for review.

If you have any questions, please do not hesitate to contact me directly by phone or via email.

As authorized by Eric B. Easton, J.D., Ph.D.
Chair, Institutional Review Board

Marc P. Lennon

Marc P. Lennon
Coordinator, Institutional Review Board

cc: K. Summers

University of Baltimore
1420 N. Charles St.
Baltimore, MD 21201-5779

Appendix C: Kick-Off Meeting Question Script

Administrator Team Questions

Introduction

Thank you for taking the time to meet with me in order to discuss you're requirements of an effective Curriculum Mapping solution for Monarch Academy.

My name is Ian Carnaghan and I am a Graduate Student in the University of Baltimore's Information and Interaction Design DS program. I am attempting to find out information about how a web based curriculum mapping applications might assist Monarch teachers in building curriculum maps for their classes.

The purpose of this meeting is to obtain basic requirements or needs of Monarch Academy in terms of curriculum mapping. As we move forward I will be working with you to further refine these needs into functional requirements, which will eventually form the foundation of the system we are developing.

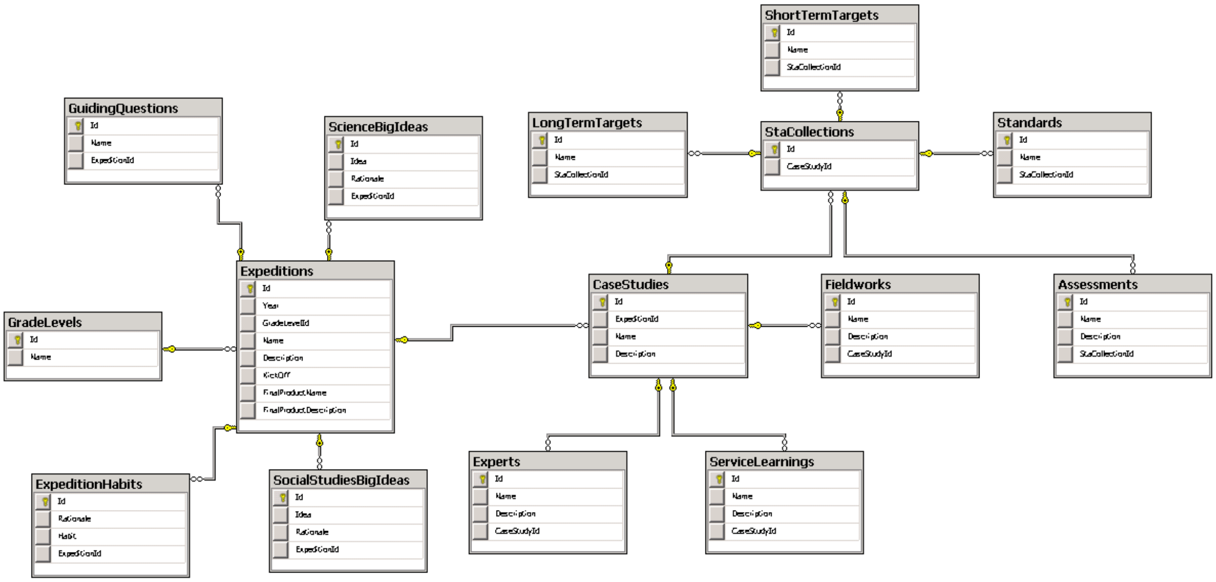
Before we begin, let me note that I will be taking notes to gather and then later analyze information from our discussion. Our session should take about one hour.

Thank you.

Questions

1. Why are you interested in a web-based curriculum mapping system?
2. How do you currently manage curriculum mapping at Monarch?
3. What features would you like to see in a web-based CM system (be specific)?
4. Where would users physically access a web-based curriculum mapping system?
5. How would your day-to-day work change if you had access to a web-based CM system?
6. Why would this tool be useful for teachers? What obstacles do you foresee when getting buy-in from teachers?
7. Would parents benefit from a public-facing section of this tool?
8. From your perspective, what would you imagine as the ideal 'dashboard' or set of commonly used features / tools (What are the most important tools to you?).
9. In terms of user roles, what features would fall under administrator access only vs teacher-specific tools? What features would parent/public users access?

Appendix D: Expedition Mapper Entity Relationship Diagram



Appendix E: Field Survey

Curriculum Mapping Survey

Introduction

Thank you for taking the time to complete this short survey. Your answers will contribute to building an effective Curriculum Mapping solution for Monarch Academy. No personally identifiable information is being requested nor will any such information be used in published research.

General Questions

Gender: Male Female Current Grade Level _______ # Years Teaching ______

Age Range: 18-29 30-39 40-49 50-59 60+

What is your comfort level in using Web Applications?

(Least Comfortable) 1 2 3 4 5 (Most Comfortable)

How likely are you to use Web Applications in your day to day teaching?

(Less Likely) 1 2 3 4 5 (Most Likely)

How often do you use a mobile device (iPhone, iPad, Android phone, Kindle, etc.) to access Web Applications?

(Not Often) 1 2 3 4 5 (Very Often)

How familiar are you with curriculum mapping?

(Not Familiar) 1 2 3 4 5 (Very Familiar)

Curriculum / Lesson Planning Questions

1. How do you currently manage lesson planning and curriculum mapping within your class and grade level?

2. What features do you believe would be useful to you in a web-based Curriculum Mapping / planning system (be specific)?

3. Where would you ideally physically access Monarch web-based applications including grade systems, email, administrative?

4. What resources and tools are essential to you today when planning curriculum and lesson planning both within your classroom and within your grade team.

5. What obstacles or issues with a web based curriculum mapping / lesson planning would hinder you from adopting this over your current processes? Be as specific as possible (think about annoyances other web applications might cause you on a day to day basis).

Appendix F: Consent Form

Whom to Contact about this study:

Principal Investigator: Ian Carnaghan
Telephone number: 240-355-6961
Email Address: ian.carnaghan@ubalt.edu

Faculty Advisor: Kathryn Summers
Email Address: ksummers@ubalt.edu

CONSENT FORM FOR PARTICIPATION IN USABILITY TESTING

An Expeditionary Learning approach to effective curriculum mapping

I. INTRODUCTION/PURPOSE:

I am being asked to participate in a research study. The purpose of this study is to explore the needs and requirements of teachers at Monarch Academy in order to define and develop an effective curriculum mapping solution for Expeditionary Learning. I am being asked to volunteer because I am a teacher at Monarch Academy and will be providing insight from my own perspective in this role. My involvement in this study will involve participation in a usability test that will last no longer than one hour.

II. PROCEDURES:

As a participant in this study, I will be asked to complete a series of tasks using a web based curriculum mapping tool. My participation in this study will last for one hour.

III. RISKS AND BENEFITS:

My participation in this study does not involve any significant risks and I have been informed that my participation in this research will not benefit me personally, but my participation will help contribute to a curriculum mapping solution for Monarch Academy that will benefit teachers and administrators.

IV. CONFIDENTIALITY:

Any information learned and collected from this study in which I might be identified will remain confidential and will be disclosed ONLY if I give permission. All information collected in this study will be stored in a locked file cabinet in a locked room. Only the investigator and members of the research team will have access to these records. If information learned from this study is published, I will not be identified by name. By signing this form, however, I allow the research study investigator to make my records available to the University of Baltimore Institutional Review Board (IRB) and regulatory agencies as required to do so by law.

Consenting to participate in this research also indicates my agreement that all information collected from me individually may be used by current and future researchers in such a fashion that my personal identity will be protected. Such use will include sharing anonymous information with other researchers for checking the accuracy of study findings and for future approved research that has the potential for improving human knowledge.

V. <u>COMPENSATION/COSTS:</u>
My participation in this study will involve no cost to me. I will be compensated with a $25 Amazon gift certificate.

VI. CONTACTS AND QUESTIONS:
The principal investigator, Ian Carnaghan has offered to and has answered any and all questions regarding my participation in this research study. If I have any further questions, I can contact Ian Carnaghan at 240-355-6961 or email ian.carnaghan@ubalt.edu.

For questions about rights as a participant in this research study, contact the UB IRB Chair: Eric Easton, Chair, University of Baltimore Institutional Review Board, 410-837-4874, eeaston@ubalt.edu.

VII. <u>VOLUNTARY PARTICIPATION</u>
I have been informed that my participation in this research study is voluntary and that I am free to withdraw or discontinue participation at any time.

I will be given a copy of this consent form to keep.

VIII. <u>SIGNATURE FOR CONSENT</u>
The above-named investigator has answered my questions and I agree to be a research participant in this study. By signing this consent form, I am acknowledging that I am at least 18 years of age.

Participant's Name: ______________________________ Date: ____________________

Participant's Signature: ___________________________ Date: ____________________

Investigator's Signature: __________________________ Date: ____________________

Appendix G: Usability Test Script

Purpose of experiment
Exploratory research on the usability of a curriculum mapping prototype for Monarch Academy.

Website
Expedition Mapper http://deploy.expeditionmapper.com

Recruitment
8-10 teachers at Monarch Academy

Expedition Mapper Usability Test Script
Thank you so much for coming in today. My name is Ian. I am a student at the University of Baltimore. I have been working closely with teachers and administrators from Monarch Academy for the past few months to develop a curriculum mapping application for Expeditionary Learning. I wanted tell you a little bit about what you will be doing today answer any questions you have before we get started. For this session, I will be asking you to do a few things using a curriculum mapping prototype. The prototype is designed to provide a user friendly experience for teachers who would be using it to record details of their expeditions each semester. The prototype provides both data entry functionality as well as basic search and retrieval features. Some features will not work fully at this point in time. The data entry section of the application provides sections for expeditions as well as non-expedition units or strands, however for the purpose of this test today, only the Fall Expedition section will be used.

I want to find out if it's easy or difficult for people to use the prototype to enter information about expeditions as well as to find the information they need. If something doesn't work or seems difficult, it is most definitely an application design fault, not yours. That means there's no such thing as a wrong answer. By doing this you are really helping me understand what works and doesn't work well with the system. Nothing you say about this prototype will hurt my feelings. I want to know what you really think. If you have any questions while you are working, please tell me. I may not be able to help, but it will help me a lot to know what questions you have.

We will be here together for about 20-30 minutes.

Do you want to ask any questions before we start?
Thanks again for coming in today, I really appreciate your help.
We are going to start by setting up the equipment.

[CONFIRM TEST SITE IS SETUP]

http://deploy.expeditionmapper.com

[GIVE PARTICIPANT CONTROL VIA CONFERENCE JOIN.ME AND DIRECT TO URL]

Let's get started.

[BEGIN TEST]

1. Locate the fall expedition's Big Ideas for Science. Add a new Big Idea under 'Constancy and Change' called 'Forces of Nature continuously change the earth' and add a rationale for this.
2. You want to know if lecturer Richard Quinn has been assigned as an expert under the Fall expedition's Ancient Greece case study. Use the system to navigate to service learning and confirm if Richard has been added. If he has not, add a record for him.
3. Non-Profit Organizations are no longer included as service learning. Locate Non-Profit Organizations inside the Fall Expedition's Ancient Civilization Case Study and delete it.
4. You realize that the final product for Ancient Civilizations fall Expedition is missing a reference link to ushistory.gov. Locate the final product description and add a hyperlink to ushistory.gov.
5. You need to plan for a new expedition on community. You heard one of the third grade teachers mention they taught an expedition on community this year. Try to locate this expedition on the system.
6. Your team leader has requested a list of all items in the system that includes Mathematics Common Core 2.OA.C3 and 2.OA.C4. Retrieve a list from the system that matches these common core standards.
7. The Ancient Greece Case Study under the Fall Expedition is missing information under the STA grid. Fill out some Standards, Targets and Assessments for this Case Study.
8. Add a new expedition for the spring and one case study. The expedition can be based on previous expeditions taught in your class or based on future anticipated expeditions.

Informed Consent

Thank you for taking part in a study to evaluate the use of curriculum mapping online. The results of this study will be used only for the purpose of improving the application for Monarch Academy and to contribute to a doctoral dissertation.

The facilitator will walk you through a series of tasks, take notes and answer questions if possible. There are no right or wrong answers in this session. We are looking to evaluate the product only, and ensure that its design meets your needs. This session will be recorded.

These tests pose no known physical or psychological risks and have no harmful effects. If at any time during the test session you decide that you no longer wish to participate in this study, you may withdraw from participation at any time, for any reason, and without penalty.

If you have questions about this test, you may contact the following individual:

Dr. Kathryn Summers ksummers@ubalt.edu 410.837.6202

Thank you for your participation.

I, ____, consent to participating in a usability test activity at the University of Baltimore, and permit Ian Carnaghan to record me and document my answers to question presented in the session.

I also permit the Ian Carnaghan to video tape the session. I understand that the video of this session will be used primarily for research purposes but may be included in future publications. I further understand that at no point in time will my name be associated with a video of my test session.

________________________________ ________________________________

Print Name *Signature*

Appendix H: Agile Sprints, User Stories, and Kanban Tasks

Sprint	User Stories	Kanban Tasks	Resulting Changes
#1	Teachers can login to their customized dashboard. Teachers can view and edit basic expedition and case study properties.	Redesign MyEL/Homepage. Create Expedition Page. Develop Case Studies. Redesign Data Tables. Design Standards Grid.	Prototype 2
#2	Teachers can see basic First Six Weeks (FSW) semesters. Teachers can enter more detailed information into their expeditions.	Add FSW Screen. Add Habits. Add ability to add Standards and Target to Final Product. Develop Big Ideas drop-down list. Add subject area placeholders.	Prototype 3
#3	Teachers can see and edit Winter and FSW semesters. Teachers should be able to edit and update Standards Targets Assessments (STA) grids for case studies. Teachers should be able to pick from drop-down lists of preselected values in applicable fields.	Refine homepage to incorporate non-expedition subject areas. Redesign Big Ideas for selections. Update Standards and Targets in final product. Develop STA grid for case studies. Update FSW to include guiding questions, assessments, habits & STA.	Prototype 4
#4	Teachers should be able to clearly see different non-expedition and expedition areas. Non-expeditions should only require fields relevant to them. Teaches should be able to create strands for non-expeditions, similar to expedition forms.	Rename homepage area to MyCurriculum. Order non-expedition subject areas in alphabetic order. Indicate mandatory fields in expeditions. Create non-expedition subject area sections. Develop strands for non-expeditions. Refine habits. Update STA grid.	Prototype 5 & 6

#5	Teachers and administrators should be able to access top level mapping and reporting. Administrators should be able to modify and enter new options for selection fields. Mapping should provide facets for searching and filtering. Data entry screens should be optimized for effective and meaningful reporting. Reports should generate high level STA across case studies.	Develop basic mapping reporting page. Add relevant facets to mapping. Provide mock-up results page. Admin functionality to include adding of custom big ideas. Consolidate STA assessments and case study assessments. Rename resources to resources/ contacts in fieldwork, experts and service learning. Add ability to assign semester to strand (fall or spring). Develop architecture of ASP.NET application.	Prototype 6 & Interactive Prototype
#6	Administration team should have the ability to create new non-expedition subject areas. Mapping should allow for gap analysis. Administration team should be able to access aggregate reports via a dashboard.	Develop entities for data entry in ASP.NET. Create context and database mappings. Integrate responsive framework. Refine and update common core list from state standards website. Add assessment facet. Add tagging to assessments. Determine desired functionality for and/or faceting. Determine multiple textbox for different expedition areas.	Interactive Prototype

Appendix I: Cross-Curricular Meeting Observation Notes

Date: 1/8/2014

Initially teams at the start of the school year review CC and Voluntary State Content Standards in order to develop overarching expedition themes. K's standards were heavily about my community so they chose crabs and osprey because they're such a prevalent part of Annapolis and Anne Arundel County economies and are very visible to students. The1st grade standards included a great deal of life cycle investigation so they chose the Monarch butterfly as an ideal model of life cycles, because it's the butterfly the school is named after. The 2nd grade standards had a great deal of fairy tales, habitat, and food chain investigation. This team chose to study deciduous forests to incorporate all of these themes.

- Hallway teams – K-2 grade meet together, 3-5, etc.
- Pitch your expedition to other people and get critique from people not directly involved in the planning.
- To see where kids are coming from and where they are going instructionally – know grade above and below.
- There are 3 K teachers, 3 1st grade, 3 2nd grade, reading specialist, instructional coach, administrator (Joel), cultural arts team (music teacher, PE teacher, art teacher, media teacher).
- Each grade explained overview expedition.
- Protocol where the team presents for 10 minutes, question-and-answer for 5 minutes, another 5 minutes people allowed to give suggestions, notes for help, (expert you could use, etc.).

2nd Grade

- Spring Expedition – into woods, creatures and echo system of a deciduous forest.
    - Field work, experts, topics/concepts covered that connected to CC.
- Concept: Deciduous Forest.
- Final product: Social Media website spoof.
- Expert: Arborist.
- Fieldwork: Going to national history museum with art teacher to sketch realistic animals.
- Academic goals:
    - Literacy: Writing a 5 paragraph essay introducing author's purpose, researching.
    - Social Studies/Science ideas: Interdependence within a food web, ecological human footprint.
    - Math: Measurement and geometry (comparing creature sizes, using measurement to compare living things, geometry to quantify and describe living things in ecosystem).

Comments QA

- Lots of suggestions for fieldwork – live near deciduous forest. Put a web cam in a forest.
- Question about integrating other forms of math through problem solving about a new development that's cutting down deciduous forests to build.
- Authentic service that 2nd graders could do connected forest conservation.

1st Grade

- Spring Expedition – The Monarch Butterfly: Investigating the life and legacy of a Monarch butterfly (specific type of butterfly that makes a journey from North America – Mexico every year).
- Concept: The Monarch Butterfly.
- Final product: Calendar that shows the various stages of the butterfly's life. Plan is to put into Spanish and English and sell to raise money to support conservation of Monarch habitats.
- Expert: Entomologist.
- Fieldwork: Butterfly house pavilion.
- Academic goals:
    - Literacy: Writing descriptive sentences.
    - Social Studies/Science ideas: Impact of ruined habitats, life cycles.
    - Math: Comparing numbers, patterning (for making predictions for the future of Monarch butterflies).

Comments QA

- Concern about calendars – considering a different product as calendars had been done before and didn't showcase a lot of knowledge – just a lot of pictures. Try to add more juicy captions/more information.
- Expedition is in 5th year and so discussion about ways to make the expedition deeper since it's been in play for so long. Considerations tying a language piece into it. Outcome is they are going to try to make some connections to schools in Mexico. Spanish teacher is going to teach greetings – setup a Skype connection and a translator to discuss the butterfly with another culture. (Tried last year with a partner school – didn't work – this year try again with IT person and translator.)

Kindergarten

- Spring Expedition – Maryland Native Species: blue crab & osprey.
- Concept: The Blue Crab and Osprey.
- Final product: Creating a coloring book that teaches about the blue crab and osprey.
- Expert: Crab fisherman; Ranger who specializes in the osprey.
- Fieldwork: Aquarium (Baltimore).
- Academic goals:

- Literacy: Identifying beginning sounds & basic sight words related to crabs and osprey.
- Social Studies/Science ideas: Labeling the body parts of the crab and osprey, telling why they are important in Maryland.
- Math: Counting to ten, basic patterns.

Comments QA

- Discussion about undertaking of a museum as a final product instead of the coloring book because the coloring book didn't show a tremendous amount of the learning that occurred last year. Undecided and then decided increase grade-level themes.
- Discussion about whether to just focus on either crab or osprey. Decided to use both because at K level can't dive too deep into the topics. (e.g. crab-eyes, legs, shell vs internal organs, etc.).

Cross Grade-Level Themes

- All focusing spring expeditions on animals, whether good or bad. Good because of consistency, negative missing out on non-living themes that primary students would benefit. In the end a decision was made it was a positive thing for them to examine animals in a stair-stepping pattern. Kindergarten – just MD, 1st – animal that migrates from here (country) to another country, 2nd – looking at much more global thing (all deciduous forests have similar eco-system).
- Lot of realistic drawing as parts of products and projects, wondered if there were different ways of getting at the same skill so kids aren't doing that three years in a row. Change was made – 1st grade decided going to try out photography for calendars instead of realistic drawings. Looking into including a photography expert who can do small unit on photography. Bring cameras to fieldwork so they can take photos of butterfly instead of drawing them. K is going to do more modeling/sculpture for their final products. FP is now going to be a museum that showcases the crab and osprey through 3d sculptures, etc.
- Really excited about how much more in-depth the expeditions are this year than last year. All three are building on expeditions that were piloted last year so stronger this year. Excited about adding/fine tuning.
- Cultural Arts integration – excited to integrate cultural arts in a much more authentic way this year (e.g. music teacher going to teach personification of animals in music during 2nd grade expedition). (The art teacher is going to make animal masks with the kids for second grade, and going to work with K to create some sculptures (nest and egg) for crab and osprey).

Observations for Improvement

- Feedback functionality

- Online discussion

Appendix J: Second Grade Weekly Team Meeting Observation Notes

1/14/2014

Participants: Three 2nd grade teachers and cultural arts team.

What is the up-to-date overview of our expedition?

- Finalized final product:
  - Students work in pairs to research and develop a social media page for a particular animal in the deciduous forest ecosystem.
  - Social media page to include an about me section, status update based on chosen animal's realistic whereabouts, postings on animals pages that are higher or lower than you on the food chain, a fictional story about something that their animal did, a picture and caption depicting what their animal had for dinner, and a "selfie" shot of the students wearing their animal masks in a scene showing their animal's habitat.
- Decision on Fieldwork:
  - Three separate visits to Patapsco State Park.
  - One visit to the natural history museum.
  - One visit to the National Zoo.
- Experts
  - Two different Rangers will visit school to discuss deciduous forests, animal food chains within the forest.
  - Arborist will discuss identification of different trees and human use of different trees.
  - Tree man will discuss the positives and negatives of cutting down trees in human habitat.

Current Action Points (things need to do)

- Fieldwork Scheduling
  - Physically wrote applications for the 6 different fieldwork visits.
  - Calculated the overall cost of students and our expedition budget.
  - Add fieldwork to the whole school calendar (so people would know when weren't there).
  - Invited the art teacher to join us on two arts integrated fieldworks.
- Adding experts/contacting new experts – include:
  - A representative of a development construction site.
  - Hunter.
  - Social media expert.

- Back-mapped the Final Product: Figured out skills and concepts that students needed in order to create that product effectively and at a high quality.
    - Literacy: Writing a five paragraph informative piece, writing a piece that entertains using and creating text features, summarizing, researching, citing research, making connections between what they read and write.
    - Math: Measurement and comparing measures, geometric concepts like symmetry, shape, line and form; fractions; problem solving.
    - Science/Social Studies: Interdependence, food chains, habitats, adaptations, life cycles, needs, conservation.
- Art teacher mapped out her spring units to coincide with when team needed realistic drawings for the profile pictures for the final product and animal masks for "selfie" picture for the final product.

Upcoming Action Points

- Get approval for fieldwork.
- Schedule dates for expert visits.
- Schedule and flesh out the weekly concepts to be taught in each subject area (lesson planning).
- Organize/fit museum projects into the weekly lesson planning schedule – mini back-mapping of the museum and student needs for debate.
- Assign Roles and Tasks: Teacher A will get approvals, etc., setting dates for back-mapping.

Concerns and Tweaks (playing devil's advocate – reviewing decisions)

- Determine how to showcase final product (going back and forth between setting up a computer café style thing to showcase, or having three separate classrooms – one internet café where parents could see social media pages the kids made for the animals, one would be a museum for the artwork created throughout the expedition, one room would host a debate about human responsibility toward conservation of the deciduous forests). Decided to do three room setup.
- Cost of transportation for fieldwork over expedition budget. Do students cover part, take from other 2nd grade budgets, or fundraise? Final decision – take from 2nd grade budget (fall) and that covers most of the overage for spring. Going to charge students a nominal amount more for fieldwork to make up the final cost.

Back-mapping – what skills do students need to do the overarching expedition items.

- For students to be able to post a hash tag – need an understanding of titles and main ideas – in four or less words they need to describe exactly what the picture is about.
- To understand deciduous forest, need to understand habitat, interdependence, etc.
- Much of EL is in the Lesson Planning piece – needs to be more detailed.

Observations for Improvement

Need more details – connections within and between grades, etc. Minutes of weekly team meetings would be helpful.

Appendix K: GoF Design Patterns

Creational	**Structural**	**Behavioral**
Abstract Factory	Adaptor	Chain of Responsibility
Builder	Bridge	Command
Factory Method	Composite	Interpreter
Prototype	Decorator	Iterator
Singleton	Façade	Mediator
	Flyweight	Momento
	Proxy	Observer
		State
		Strategy
		Template Method
		Visitor

(Gamma et al., 1994)

Appendix L: Expedition Mapper Road Map

Core Features

Feature	Version	Source
Core Data Entry Forms	Alpha	Sprint
Reporting and Mapping	v1.0	Sprint, Usability Testing
Roles Implementation	v1.0	Sprint
Administration Panel	v1.0	Sprint
User Account Authentication	Alpha	Sprint
Custom Field Generation	v1.0	Sprint, Observation
Business Logic	Beta	Sprint, Usability Testing
Multiple Device Compatibility	Alpha	Observation, Field Study
Import Feature	v1.0	Sprint, Observation

Extended Features and Fixes

Feature	Version	Source
Integrated Calendar	v2.0	Observation
Advanced Charting	v2.0	Sprint
Integration with Other Educational Models	v2.0	Sprint
*** Cohesive Dashboard UI**	Beta	Usability Testing
*** 508 Accessibility**	v1.0	Usability Testing
*** Additional Help / Prompts**	v1.0	Usability Testing
*** Updated Contrast & Control Coloring**	Beta	Usability Testing
Online Community	v2.0	Observation
Document Attachment Management	v2.0	Field Survey

* Enhancements iteratively added from research activities

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