AN ANALYSIS OF UBIQUITOUS LEARNING ENVIRONMENTS AND STEM CONFIDENCE BUILDING AMONG HISPANIC STUDENTS

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The following individuals read and discussed the dissertation submitted by student Torrence G. Temple, and they evaluated the student's presentation and response to questions during the final oral examination. They found that the student passed the final oral examination.

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DEDICATION

В конце пути я посвящаю это достижение своей жене, вдохновению всей моей жизни. Пусть наша работа изменит жизнь студентов, а наследие заставит наших детей гордиться.

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I started this program looking up a huge hill. Standing at the bottom was a man who was not much of a reader because he had dyslexia, not being much of a writer because he was a builder, and crushing hand pain that resisted his every keystroke. Alone, this impossible journey would have never happened. I acknowledge my guides that helped me ascend this elevation.

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waited, unsure why, but I feel it was all part of the bigger plan, and I love it when a plan comes together.

ABSTRACT

The fastest-growing demographic in the United States is also the one with the biggest struggle with academic success, particularly in STEM-related subjects. Pre-study research observed that one of the most significant factors facing Hispanics is their set of psycho-social behaviors influenced by cultural heritage. In a response to this challenge a solution was developed and over the two years of its implementation failure rates among Hispanic students dropped from department-wide chemistry class average of 40% down to under 10% in the treatment population. The purpose of this study was to identify a theory that identifies the relationship between individual factors that influenced the change in student success. Nineteen students were interviewed regarding their experiences, vetted for Multi-Active behavioral tendencies, and then their interview data were compared against their student achievement records reflecting their before, during, and after program exposure. The findings indicated that much of their success was due to uLearning program design elements that distinctly enabled the Multi-Active psycho-social tendencies to co-exist the behavioral expectations of a Linear-Active academic environment. Key criteria included design characteristics that focused on emotional engagement, immediate feedback on assessments, a centralized learning site, and learning content that supports real world application of learned material.

Keywords: Ubiquitous Learning (uLearning), Multi-Active, Linear-Active, STEM, Hispanic culture, Self-efficacy, Confidence behaviors

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ATV	Affect Theme Value results from magnitude coding categories with student interview data.
ATN	Agent Training Notebook – tangible note taking artifact for students
CBE	Confidence building Experiences – a label given to student responses with an Affect Theme Value larger than 3.0
CRE	Confidence-restricting Experiences – a label given to student responses with an Affect Theme Value less than 3.0
SRT	Survival Readiness Test – built-n fast response formative assessments

INTRODUCTION

Instructional technology—tools for learning, whether technical or methodological—are applied in specific situations in accordance with the user's training. A teacher in a credentialing program might provide the opportunity to learn to use a particular educational technology. Google Slides, for example, might be demonstrated as a way to present media in a linear and logical format. This tool offers media and educational content in a unilateral manner. Instruction on the use of this technology also demonstrates methods for learning content in a linear format: The content is presented, students observe it, and are usually encouraged to produce an artifact to show their understanding: Watch, process, produce, and repeat.

Numerous technologies have been designed to assist in the educational process. This study presumes that the philosophy behind current educational technology design is tightly intertwined with what one might consider "traditional" production-oriented expectations. Educational technology would need a significant overhaul if it were to address the issue and must be adapted to deploy technologies that are more suited to psycho-social behavior traits that do not consider production. Such an overhaul has been attempted in a curricular area that Hispanic students currently struggle with much more than other students do. Math and other STEM-related high school courses are particularly tricky for Hispanic students, who also express low self-expectancy regarding these subject areas (Saw & Chang, 2018). The uLearning approach led to a chemistry curriculum aligned with the Next Generation Science Standards (NGSS) for California

Schools and was also heavily influenced by STEM principles. This study develops a grounded theory that may help advance educational technology design for Hispanic students struggling with STEM subjects through addressing academic struggles prevalent among multi-active (Hispanic) students by first understanding their cultural influences.

Background and context

Hispanic students make up at least 20% of the school population in 23 out of the 50 U.S. states. 60% of these students are Mexican, 10% are Puerto Rican, and 17% are Hispanics from other Central American countries, according to the National Assessment Governing Board (2013). In 1990, the *Equity of Educational Opportunity Study* (EEOS), better known as the *Coleman Report* (1990), indicated that family culture, or background, was the strongest influencer of academic success. Its impact was more significant than school facilities, teachers' characteristics, or feelings about student peers. The report was among the first to overtly report that minority students, Hispanic students, were among the lowest-achieving academically. The Hispanic achievement gap was validated again and again in research throughout the 2000s (Haile & Nguyen, 2008; Hawley et al., 200; Morales & Saenz, 2007; Neufeld et al., 2006; Stiefel et al., 2006). The U.S. government included specific mandates in the No Child Left Behind Act of 2001 (NCLB) to develop methods and strategies to address learning gaps for at-risk groups like Hispanic and Latino students. According to the U.S. Census Bureau (2006), Hispanics' educational attainment is significantly below that of the country's population as a whole. Only about 75% of Hispanic students complete high school opposed to an average of about 94% of the total population. Furthermore, about 25% of the total population has a bachelor's degree or a higher, but only 6% of Hispanics do. Whatever methods U.S. schools had been using appeared to be ineffective up through the publication of this report.

Expectancy in Hispanic Students

In 2018, Saw and Chang published a paper in the *Hispanic Journal of Behavioral Sciences* suggesting that Hispanics had lower achievement in STEM courses and had a lower sense of expectancy or self-efficacy. More specifically, the article stated that Hispanics' expectancy scores were 2.4 to 2.6 times lower than non-Hispanics. Saw and Chang (2018) used a framework called expectancy-value theory which John William Atkinson developed in the 1960s. The theory aims to understand individuals' motivations in terms of their expectations for success and the degree to which the individual perceives a given task to be useful or enjoyable. In other words, they didn’t score well because they didn’t believe they *could* achieve well. Additionally, the Hispanic students may have believed they could do well but did not see the pertinence in exerting the effort to succeed.

Studies performed by Boutakidis et al. (2013) analyzed a sample of 61 students from a southern California middle school. They found that Hispanic students (both male and female) had lower GPAs than non-Hispanic students. The article specifically noted that the most significant GPA gap between Hispanic and non-Hispanic students was in the STEM areas. The study explained that factors contributing to this discrepancy were primarily due to a lack of engagement. There appeared to be a general aversion to wanting to participate, and in the simplest of terms, the Hispanic students did not seem to have the other students' subject-level expectancy.

Moreover, Safavian and Conley (2016) completed a study that used expectancy theory to investigate 926 seventh-grade algebra students' enrollment. The paper results displayed a significantly lower algebra enrollment rates in Hispanic populations than in other non-Hispanic students. The paper stated in their findings:

> Our findings suggest that students' expectancy-for-success beliefs (for Hispanics and their peers) play a critical role in their subsequent enrollments (either directly through course-taking behavior or indirectly through other processes that lead to their placement within that course, e.g., performance, effort, etc.). Thus, this finding constitutes an important direction for future research—to elucidate the mechanisms through which expectancy beliefs inform subsequent enrollments after achievement and STVs have been accounted for. (p. 33)

Interestingly, Stevens, Olivarez, Lan, and Tallent-Runnels (2004) found that prior achievement, mental ability, and mathematics self-efficacy could explain 50% of the variance in math scores for white students yet, only 29% for Hispanics. The find was curious. One might think that being "good" at something would naturally promote a more prominent display of subject-level expectancy, as was the case for the White students. Something else was at play. Another factor not present in White populations appeared to be causing Hispanic students to disengage. Either the "fun" and "interesting" aspects had a more substantial influence than previously thought, or perhaps it was something else entirely. Maybe it was a more passive quality, something that exists quietly in the background of one's personality and was quite different from that possessed by the White counterparts in the study.

For clarification purposes this study sees confidence building experiences as different but not disconnected from expectancy. Expectancy grows as consequence of sustained positive confidence building experiences both within the domain of the skill to be learned and in confidence that the learning material is not considered useless in the real world; that the learning domain has an applicable and understood value that is meaningful in an emotionally significant manner.

One plausible reason for these results could be psychosocial in nature. Alfaro and Umaña-Taylor, 2015 suggested teachers could create greater STEM expectancy through more personal interventions and support from families at home. However, this conclusion lacked real-life applicability because it considered the matter through a lens that did not reflect the Hispanic cultural mindset regarding the relationship between school and home. It could be that Hispanic expectancy could be not only tied to factors presented by Atkinson in the 60s but might also be related to something far more deeply rooted in the psychosocial behavior set of Hispanic students.

San Jacinto has a rather homogenous Hispanic population, and cultural heritage could substantially impact how students behave at home and how those behaviors were transferred to the school as the students', as Lewis (2010) suggested, "behavioral operation system." The development of one's behavior incorporates numerous influences; however, few behaviors influence one's cultural surroundings (Han & Ma, 2015; Lewis, 2010). Han and Ma posited that cultural neuroscience findings suggest there are both indirect culture-brain interactions through behavior and direct culture-brain interactions. These culture-behavior-brain (CBB) interactions form a feedback loop that provides a theoretical lens for viewing how human identity is formed. In essence, the brain fits and modifies culture through behavioral influences. Interactions with others in one's culture provide emotionally rewarding or rejecting feedback to the developing mind. Not until the child reaches 18-22 years-old is the pre-frontal cortex wired to operate in a functional manner. As this area is one of the few logic control centers that influence the HPA axis (the emotional regulatory center), the child's foremost decision-making apparatus is the emotional regulatory system (Medina, 2011; Han & Ma, 2015). Without an operational pre-frontal cortex, a young brain remembers and retains behaviors that are rewarded with emotionally rich positive attention and reduces or extinguishes those met with negative emotional feedback (Medina, 2011). Imagine a child growing up in an environment where family heritage is highly valued. The child sees adults and older siblings participating in family-related traditions in ways that have been preserved for a long time, and it would appear that participation in traditional activities are coveted and emotionally rewarded.

The school's Hispanic student population is nearly quadruple the national average, at 86%. 84% of these students are in the Free and Reduced Lunch Program, according to CBEDS data collected by the San Jacinto School District last year. Preliminary informal conversations with SJHS sophomores enrolled in NGSS chemistry revealed that Hispanic families tend to see school and home as two distinct and separate entities. The tone of the discussion indicated that Hispanic parents are not likely to assist with school because they tend to hold subject area teachers in high regard and assume they could not properly assist at home. The students also suggested that if parents were notified that their children needed help at home, at best, the parents would engage with the student vocally, and the student would ensure them that "work had been done." The parents, who rarely had any academic understanding of the students' work, would accept this to mean that the work had been done to a high standard. In actuality, the students might invent answers or get them from others by copying work. Perhaps even more frequently, the work would simply be pushed aside and remain incomplete.

Problem Statement

Hispanics have struggled with U.S.-based educational systems for decades.

Failure rates in all subjects have been notable, but none higher than in STEM subjects (Kayaardi-Hinojosa, 2011; Wenglinsky, 1997; Machado & Chung, 2015). An argument could be made (though highly unlikely) that improvements in STEM subject matter success could not be made without a collective increase in engagement – a willful act to participate with the intent to achieve. According to the Expectancy-Value Theory (Vroom, 1966), the decision to engage must have come about by either in increase in subject area confidence (as a result of having repeated successful experiences in the subject) or the subject was made somehow more applicable or interesting to the students. In any case, the pre-study observations were unclear *how* students' positive STEM engagement findings were achieved using a uLearning designed content delivery system. This study seeks to investigate how uLearning curriculum design and its associated technologies affected perceptions of success in Hispanic high school students in an NGSS-designed chemistry course. The students were asked to reflect on their experiences within their chemistry science classes and how the uLearning design changed their sense of expectancy through confidence building experiences. The intended outcome would be to develop a generalized theory describing the mechanism that led to student's change in perceived confidence in STEM. The study focuses on elements of the uLearning paradigm described in *Ubiquitous Learning Environments and Technologies* (Hwang et al., 2018).

Research Questions

This study investigates a group of high school Hispanic students in Southern California who have or will have taken part (within the last two years) in a program that used specialized "ubiquitous learning" (uLearning) technology and design. The uLearning design philosophy for the technology appears to synchronize better with multi-active psycho-social behaviors than does a curriculum designed of a more traditional methodology. Research questions follow:

Research Question 1

The primary research question asked how the uLearning system (in the form of the AREA154: Apocalypse Division Chemistry Program) was able to produce confidence building experiences in Hispanic (Multi-Active) students?

Research Question 2

In the event that the students had confidence building experiences, did these experiences lead to measurable achievement gains, and were these gains experienced by students who matched the Multi-Active profile?

The findings associated with Research Question 1 would assist the formation of a theory that tied students' year-long STEM experiences together; it will explain how the uLearning program may have contributed to their perceived sense of subject area expectancy. Research Question 2 seeks to cross-check the validity of the theory. The students may have collectively felt one way, but the recorded grades (recorded grades) support their perceptions? Moreover, the study's purpose was to identify a theory that could help STEM content design for Multi-Active students. The Multi-Active behavioral profile should be explored to see if the study's subjects possessed these behavioral traits in reality.

Significance of the Study

The Hispanic community has been increasing and struggling with school for decades (Alfaro et al., 2006; Altshuler & Schmautz, 2006; Craft, 2011; Gandara &

Contraras, 2009; Harris & Herrington. 2006; Karatinos, 2009). The problem has been analyzed deeply and clearly defined. A clear gap also exists between Hispanic and other STEM subjects like math, chemistry, physics, and other technical and procedurally rich content areas (Saw & Chang, 2018). Saw and Chang also noted a significant lack of STEM content self-expectancy among these students: they possess little confidence in their ability to do STEM-related work, which may have contributed to their lack of success in those subjects. What was missing from the research was suggestions for how to address this problem.

Carr (2013) suggested that Hispanics' lack of success in school might be correlated to the availability of technology. The study demonstrated that technology is only helpful when teachers facilitate its use and only helped students complete their work. There was no mention of how well the students did, their improvements over time, or whether the technology-enhanced independence and self-expectancy in STEM subjects or any other subjects.

Perhaps the most significant systemic obstacle facing Hispanic students for increasing their sense of self-expectancy in the modern era of progressive education is the system itself. Lewis (2010) presented a cultural model that placed the psycho-social behaviors of cultures worldwide on a triangular continuum. This filter showed how the public school system in the U.S. is tightly aligned with the linear-active behavioral traits. In contrast, the Hispanic collection of psycho-social characteristics is nearly the polar opposite of this. This opposition may be a part of the reason Hispanic populations are struggling with school; it might be that U.S. public schools are culturally incompatible with them. However, even if the cultural disparity is a factor, it does not in itself offer a solution.

Suppose evidence within the literature suggests uLearning STEM area growth increased self-expectancy and success in STEM courses (in this study, chemistry is the focal subject). In that case, it could mean increased Hispanic achievement. Moreover, if the same happened in other subject areas, it could lead to increased achievement and self-expectancy in school and a higher likelihood of further education. At the very least, if the data suggested that uLearning promoted STEM subjects, there could likely be an increase in technical competency and perhaps a willingness to engage in more technical professional endeavors. Certainly, an argument could be made supporting the correlation between subject expectancy and a probability to engage that subject.

The significance of Hispanic STEM education among Hispanics had drawn attention from more than just the educational community. In 2007, two Harvard economists, Borjas and Katz, published a paper that can be summed up in the following passage,

> "The continued migration of Mexican workers into the United States and the inevitable rapid growth of the group of native-born workers of Mexican ancestry suggest that the economic consequences of this low-skill migration influx are only beginning to be felt." (p.53)

The article titled "Evolution of the Mexican-born Workforce in the United States" faced criticism about its alleged racial profiling of Hispanic people. However, the statistical application of Hispanic (Mexican-born) wages, birth rates, the economic impact of low-wage earners, high school drop-out rates, and the impact of low wages on the local, state, and national tax revenue, the analysis appeared to be quite sound.

Thomas Edsall of the New York Times summarized the Borjas and Katz article this way in an opinion piece called, "What Does Immigration Actually Cost Us?":

> "The effects of immigration, in general, are swamped by the impacts the Mexican-born workforce has on the slowdown of U.S. education supplies, technological change, and eroding labor market institutions (unions, minimum wages, rising outsourcing/fissuring of the workplace)." (https://www.nytimes.com/2016/09/29/opinion/campaign-stops/what-does-immigration-actually-cost-us.html)

The census numbers from 2016 support these notions, but what does this mean? In short, it means that if a solution cannot be found that encourages Hispanic students (especially Mexican-born) to stay in school and embrace math, science, technology and engineering subjects, their collective inability to acquire technology-based higher paying jobs will contribute to the increasing wage gaps, reinforce the poverty cycle, and drain local and state tax revenues (which are based on income – lower income means lower tax revenue). Lower tax revenue means less support for regional infrastructure, diminished ability to support local education, which places additional fiscal burdens on the federal government. Those in education fairly state that STEM education is important for everyone. Borjas and Katz (2007) appear to have tied STEM growth among the Hispanic community to much larger potentially devastating fiscal motivations.

Research Settings

San Jacinto High School has a 100% free and reduced lunch program. The indicators here suggested that all the participants in this study were current students at the high school and self-identify as Hispanic from Mexico or Central America.

Students who experienced the uLearning environment and were selected to participate in the data collection had:

- confidence that they understood the curriculum and the program's expectations,
- the ability to reflect on their past experiences,
- the ability to present their reflections and other observations in English,
- self-describe as "Hispanic" as their primary cultural influence.

These settings were chosen to avoid the possibility that self-expectancy in STEM subjects was affected by participants' confidence with the language in which the program was delivered.

The study used the testimony of students who participated in the *AREA154: Apocalypse Division* program while in their sophomore year. The study realized the possibility of some factual memory loss from the experience. However, it was also believed that the students would likely not have forgotten how the experience helped form their feelings of self-expectancy. A solution for helping subjects recall their experiences were accommodated for and discussed in the methods section.

The study accepted (in-line with Lewis' findings) that culture affects people's thoughts, decisions, priorities, and ultimately behavior. This view is not progressivist, rather constructivist in nature. This assumption is reinforced by research done by Han who's research suggested that culture plays significant roles in the development of certain psycho-social behaviors (Han & Ma, 2015). As such the uLearning theoretical framework appeared to best serve as a philosophical guide for helping the development of the learning technology.

U.S.-based schools have been and continue to be highly aligned with Linear-

Active psycho-social tendencies. According to Lewis, the production oriented mindset was described as a very “Linear-Active” cultural behavior. Although no official research had been collected by the staff members at the test site (SJHS), anecdotal evidence collected before the study supported this notion. Science teachers within the department considered the correlation between the Linear-Active mindset and the school system's organizational psychology to support a connection between the two overwhelmingly.

The culture or the psycho-social programming a child was exposed to at home, can significantly impact their potential for success as a student. The educational community understands those relationships, and parents' influence is one of the best predictors of success in U.S.-based schools. This study also accepted the converse: if a domestic culture doesn’t support a Linear-Active school environment, children’s success in that environment will be similarly low.

Summary

For over five decades Hispanic students were observed to have a greater struggle with the U.S. educational system than any other ethnic minority group. The progressive modern school design brought about by John Dewey in the 1950s was heavily influenced by Western European philosophies of contractual productivity and timeliness. Despite the efforts of people who have attempted to solve the Hispanic academic issue, school districts appear to trying to solve it in ways that do not consider the influence of Hispanic culture. Significant amounts of money have been spent on technology-based solutions, though, these solutions are still all concentrated on a cultural paradigm that might inherently be part of the problem.

Technology has arguably made education better, but it has unarguably made education more versatile. The tools used for distance learning, 1:1 programs, and learning management systems have radically changed teachers' options. But despite these innovations, Hispanic students continue to fall behind in STEM subjects. This investigation analyzes a group of 19 Hispanic students from San Jacinto High School who participated in an innovative program that lead to a notable level of collective improvement in chemistry. The research question posited the question asking about how this improvement was accomplished. The participants of the study ranged in their level of achievement and we all described themselves as Hispanic. Each student had participated in the AREA154 program and their experiences were extracted through structured questioning via Zoom-based interviews.

Chapter two provides the foundation for the concerns about Hispanic students. Also it explores the development of uLearning as a tool to help Multi-Active students succeed in a school system designed in a Linear-Active manner. Additional information is provided about Richard Lewis' work and how his cultural framework plays a pivotal role in revealing Hispanic cultural immiscibility in the U.S. school system.

LITERATURE REVIEW

American Schools, Hispanic Culture and Curriculum

The development of the modern school system in the United States began with the formal establishment of a centralized network by Horace Mann. Though initially based on the Prussian Model of Common Schools, American public education drew nearly all of its philosophical influence from Western Europe. John Dewey commonly called the father of progressive education, derived many of his educational influences from German philosophers, including Immanuel Kant and Karl Marx (Cohen, 2014). The fundamental design of the American educational system reflects systemic order, organization, categorization, and behavioral hierarchies that are indicative of very European psychology. One could argue that the clean lines of the K-12 system enabled the factorial production of American citizens. Furthermore, without Dewey's productivity-based organization of curriculum, it would have been almost impossible to empower a nationwide educational system synchronized to a growing population's needs.

The cultural composition of the United States has changed slowly toward greater diversity. In the last fifty years, however, cultural change seems to have been accelerating. In 1972, nearly 80% of public school students were White; by 2005, only 58% were (Gandara & Contreras, 2009). The country's Hispanic population has grown five times as fast as any other ethnic group in the last ten years (Hansen, 2005). This rapid growth has placed a great deal of stress on the education system, which is struggling to keep pace with a population that seems to face a large number of difficulties integrating into the public schools.

Although the Hispanic cultural identity spans dozens of countries all over the Western hemisphere, according to the U.S. Census Bureau (2006), Arizona rates in the top five states for overall Hispanic population gain in the country. Hispanics come to the U.S. from all over the world, but 64% are of Mexican descent. Similar numbers hold for all the states along the U.S.–Mexico border. Many school districts in the Riverside area of Southern California, a center for agriculture, report Hispanic population concentrations far higher than the national average. The San Jacinto Unified School District in Riverside County has a population of 84% Hispanic students, nearly three times the next largest ethnic group (2019–20 enrolment statistics, cde.ca.gov). Demographics such as socioeconomic status, education levels, language barriers, and other student success components have been analyzed, but despite the efforts of many researchers, this student population does not appear to be closing its achievement gaps.

Completion rates of public education are significantly lower for Hispanics than for the population as a whole. Only about 75% of the Hispanic population in the U.S. completes high school, as compared to about 94% of the total population. This fact could be correlated to evidence that Hispanics have significantly lower household incomes than non-Hispanic Whites. Hispanic workers' incomes reflect this discrepancy: Hispanics earn substantially less than average for the total population. The median annual salary for Hispanics in 2007 was $37,800, as compared to $52,400 for Whites (United States Census Bureau, 2006), only 57% of Hispanics ages 25 and older have graduated from high school, and only 11% have a bachelor’s degree (United States Census Bureau, 2004). Rapidly changing demographics, federal legislation, and misperceptions about language diversity have contributed to the problems educators face in meeting the needs of English language learner (ELL) students (Karathanos & Mena, 2009).

Lewis' work was partly motivated by his frustration with previous cross-culturalists creating more confusion than clarity when trying to gain insights into foundational characteristics of cultures. After visiting 135 countries and working in more than twenty, Lewis simplified all the world's cultures into three clear polar extremities. Figure 1 presents the Lewis model and assigns countries and their cultural attributes to it on a triangular gradient.

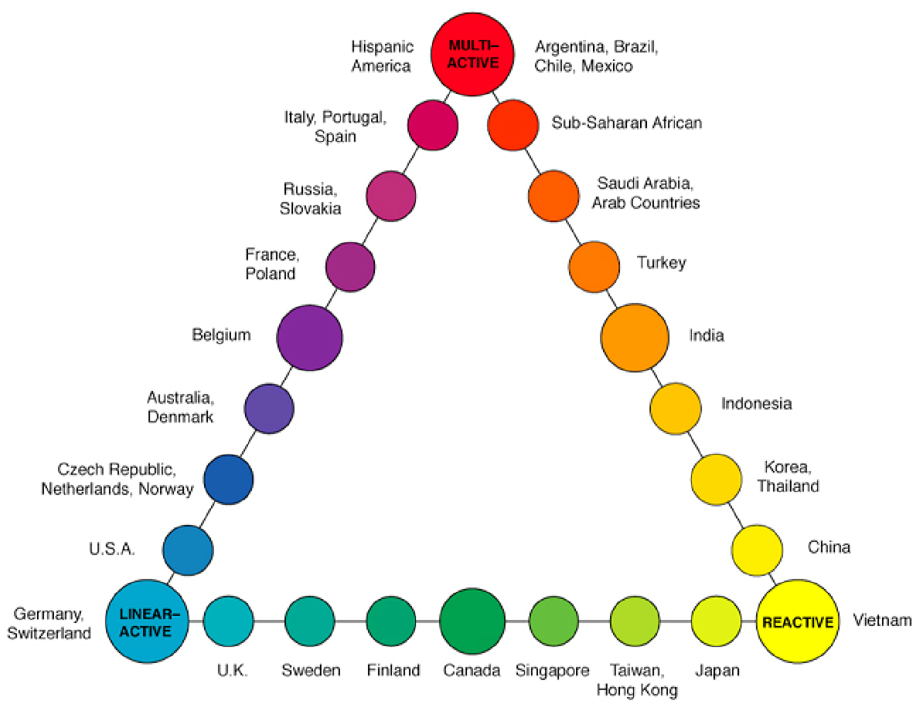


Figure 1. Lewis's Cultural Model – simplified

Lewis's work, though constantly being revised, presents a model by which people can understand the behavioral tendencies of other cultures. Moreover, and perhaps unintentionally, the diagram may provide key insights into why Hispanic students do so poorly.

The term “polarity” is traditionally used in science to sort entities into two groups. A substance is either positive or negative, polar or non-polar, or organic or inorganic. The idea that something could be polarized in three directions might seem counterintuitive. However, Lewis’s model appears to suggest just this.

Most Hispanic people in the U.S. come from Mexico, and their concentration increases substantially in states that border Mexico. The Lewis model suggests that linear-active countries such as Germany, the U.S., Switzerland, and the U.K. are positioned opposite multi-active countries such as Mexico, Colombia, Brazil, and Venezuela. People from Linear-Active cultures (Lewis, 2010) display task-oriented behaviors and are organized planners who complete actions in a connected series to reach a specific goal. These cultures prefer to stick to factual discourse, are truthful rather than diplomatic, and do not fear confrontation. Linear-Active people tend to conceal their feelings and value a certain amount of privacy. They need data to make decisions, and they use accurate decisions to produce results. The Linear-Active mindset is the mentality of growth, progress, and assessment to make sound decisions and predict future courses of action.

People in multi-active cultures depend heavily on open communication and socialization to acquire information. Lewis (2010) described these people as impulsive and placing great importance on feelings to learn about decisions. Multi-Active cultures run “off the clock,” according to Lewis. They are unhurried, and adhering to self-imposed deadlines appears mostly incompatible with their traditional psychology. Multi-Active people are often late paying bills or finishing projects. Relationships with family members and close friends take precedence over other official policies, rules, and other organizational regulations. People of Multi-Active cultures are accustomed to challenging authority but will accept their place in a social or organizational structure when placed there by an influential, authoritarian “father figure” who emphasizes protecting them. Their interpersonal contracts are traditionally oral so they can avoid relationship-straining regulations in which charisma, rhetoric, and negotiated truth tend to be used to close deals. They are less intellectual and calculating and more engaging and welcoming, and they place great emphasis on compassion and human warmth.

The American educational system is clearly aligned with the lower-left section of Lewis’s triangle, designated as Linear-Active. The country’s schools are driven by deadlines, measurable objectives and standards, and assessments of the position and trajectory of everyone in the system. For example, the No Child Left Behind (NCLB) Act made “testing and accountability our national education strategy” (Ravitch, 2010, p. 30). The essence of the act was related to four concepts of public school reform: (a) stronger school accountability; (b) greater flexibility for schools to use federal funds; (c) school choice; and (d) an emphasis on science-based teaching methods (No Child Left Behind Act, 2001). Although this strategy may work for many struggling populations in the U.S., every section of this reform initiative runs counter to multi-active people's cultural mindset. It could be just the opposite of what is needed to encourage their greater engagement in a system that demands behaviors in opposition to their own.

The state of California recently adopted next-generation science standards (NGSS), which let teachers play new roles in developing science curriculums directed toward state-assigned outcomes (Pratt, 2013) intended to narrow the gap between the U.S. and the rest of the world (Christofferson, 2017). Many non-socioeconomically challenged school districts, such as the Murrieta Valley Unified School District, responded by developing science curriculums centered on phenomena such as climate change and the impact of human activity. These topics were delivered to students through standard science pedagogy (Wells et al.,1995). Low-SES school districts with large Hispanic populations suffer from a lack of student engagement, which contributes to the most substantial high school dropout rate by culture in the U.S. (Marks, 2000).

Pedagogy and the culture of learners

This investigation began with the discovery of Lewis' (2010) work on countries' underlying psycho-social behaviors, which we have superficially called "cultures." Lewis defined these behaviors as national characteristics. Although they appear to be racist, Lewis claims that they are national norms of behavior. His book was intended for business use to ensure that proper education on national behavioral norms could maximize transcultural personnel transfers' success. His theories about culture include elements of humor. For example, Asian cultures generally do not find Americans and Western Europeans very funny because much of their humor is built on sarcasm. Many of the cultural underpinnings of Asian people comes from the Confucian ideas of truth, kindness, and compassion. As such, harsh, belittling jokes tend to go against the grain for them. Lewis categorized Asians as "reflective" in their national behavioral norms.

Lewis has also published on more culturally specific concepts, like how different cultures address the idea of time (Lewis, 2014). In *Fish Can't See Water* (Hammerich & Lewis, 2013), he claimed that people who grow up in a specific cultural psycho-social mindset are blind to its inherent behavior sets. Germans do not realize that they are naturally procedurally driven and linear thinkers because they grow up and live in

Hamburg. They are practically blind to their own norms and tend only to see those norms when they come into contact with conflicting ones. Even then, they probably observe simply that everyone else is “different” in a negative way without recognizing their own norms. It is from this perspective, this framework, and this realization that Hispanic behavioral patterns and psycho-social traits can be seen to be very different from those that created the U.S. public school system.

Searches about Hispanic educational experience returned hundreds of books and articles, many of which, such as *Hispanic Education in the United States,* reported biographical information and people’s experiences of “what it is like to be” a Hispanic person in the U.S. school system (Garcia, 2001). However, this book contains little evidence that the author identified cultural differences inherent to the mingling of cultures as the reason for the perceived inequalities. Lewis (2014) suggested that cultures are prone to not seeing their own psycho-social traits. Garcia (2001) gave a clear example of this in his demands upon the educational system: “Schools must shift their emphasis to the development of broader ‘living’ processes that will enhance human relationships, critical thinking, and civic responsibility” (p.16). These are clear examples of multi-active cultural norms favoring relationships, emotional warmth, and community.

Garcia (2001) further asserted that the preservation of Hispanic (multi-active) psycho-social behaviors is more important than the academic skills responsible for the long-term success of the student:

> In a nationwide survey of families, researchers found evidence of serious disruptions of family relations occurring when young children learn English in school and lose the use of the home language. This study revealed that while the

> language minority parents recognize the importance of English (for academic success), they do not want it to be at the expense of the home language. Many parents expressed concern that their children would lose their native language (culture) and become estranged from their family and cultural heritage. (p.17)

In other words, multi-active psycho-social tendencies have favored and continue to favor non-acculturation. These cultures would fight to maintain their national behavioral norms at the expense of the student's academic success. A study by Gillard et al. (2007) supported Garcia's findings. The authors concluded that providing language support by preparing students to work in their home languages supported Hispanic cultures' psycho-social traits. The same study inferred that the individualization of classwork also supported cultural vitality in the home. Those accommodations mainly consisted of changing assignment timelines and due dates to accommodate events at home. More and more, the literature suggests that multi-active psycho-social norms are incompatible with the linear-active design of the public school system in the United States.

Gillard et al. (2007) also provided suggestions for U.S. public school teachers to address the situation. In summary, the teachers must address each student according to the specific set of national norms its family follows. There was a minimal indication that all families' needs would be the same, only that in multi-active cultures, the family comes first in whatever form it takes. The article did not explain how to accomplish this task.

The Hispanic educational paradox is well documented, but proposed solutions have often been placed on the shoulders of "technology," hoping that it might somehow present an answer. A finite amount of disclosure of this type of financial waste is available. However, after 23 years of anecdotal observation, spending money on technology in the hopes that it will fix something is not just a theory; it is what happens.

Self-Expectancy and Expectancy Value Theory

The expectancy-value concept theory was developed by Vroom in 1966 and then further expanded by Jacquelynne Eccles and her colleagues (Eccles et al., 1983; Eccles & Wigfield, 2002; Wigfield & Eccles, 2000). The theory stipulates that achievement-related choices are motivated by a combination of people's expectations for success and subjective task value in a given domain. The theory elements are broken down further into additional areas of attainment value - the importance of doing well, intrinsic value – personal enjoyment, utility value – perceived usefulness for future goals, and cost – the competition with other goals). While the theory has discrepant elements, research has confirmed that expectation for success and task value are distinct constructs (Eccles & Wigfield, 2002; Wigfield & Eccles, 2000). The theory was initially applied to identify motivational factors in workers, improve productivity, and better understand personal discussions like career choices. Elements of the theory provided insight into numerous innovations improving workplace motivation and developments on theories that govern how individuals make occupational career choices. Holland (1963) used expectancy-like psychological parameters to assess the factors governing how individuals made career choices within a relatively high degree of accuracy. The Expectancy-Value theory was not limited to work studies. The educational research community adopted the term "expectancy" and "self-expectancy" to understand student engagement and the choices better while learning new content.

The inclusion of E-V (Expectancy-Value Theory) as a formative explanatory tool in the learning sciences led to an explosion of new research that attempted to understand the student-centered decision-making process better. Much of the body of work in this area was completed by Wigfield and Eccles (2000) as they were more specifically interested in the adolescent mind's inner workings. Since then, the concept has been used to dissect motivations in student achievement, in-class engagement, academic procrastination, and particularly key to this study, the internal decision-making processes of Hispanic students related to STEM subjects.

Personalized Instruction

Computing technology has expanded the domain of possibilities in ways that the founders of constructivism might never have believed possible. Mark Weisser introduced the idea of ubiquitous learning as providing a world in which computers and associated technologies are so intertwined with students' life experiences that they have difficulty distinguishing between learning objects and parts of everyday life (Weiser, 1991). Jones and Jo (2004) quoted Weiser as saying, "The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it" (p.3).

Weiser was a Xerox PARC researcher who coined the term "ubiquitous computing" in the late 1980s. In 1993, he discussed how the relationship between computers and students would one day occur in a ubiquitous learning space, or "u-space," where the technology fades into the background and simply facilitates the learning experience. He has been credited as the initiator of the modern ubiquitous learning environment. Weiser postulated this type of learning in his *Scientific American* publications, and the internet, wireless communication, and the omnipresence of people-centric, social-sensing, over-sharing, communicative hand-held devices brought it to life

(Campbell et al., 2008).

Kidd and Chen (2011, p. 4) and Cope and Kalantizis (2010, p. 15) described personally ubiquitous learning a paradigm that promised support for teaching anything, anywhere, at any time through the use of computers, software, and services. In 2020, that definition has the ring of common sense, but ten years earlier, it raised substantial questions about the pragmatic nature of uLearning. In 2010–11, networking, online storage, and high-speed internet access were nowhere near their current levels.

The ideas of these influential thinkers were synthesized into a general framework for personalized learning.

Key ideas for a ubiquitous personal learning framework included the following:

- *Urgency of learning needs.* Used for urgent learning needs. On-demand and just-in-time learning are variants of the uLearning concept.
- *Initiative of knowledge acquisition.* Information upon request and promptly, in the context where the learner needs the information.
- *Interactivity of the learning process.* The interface must facilitate effective communication between students, teachers, and other influencers of information.
- *Situation of instructional activity.* The learning is embedded in the natural flow of an event or everyday activities, real or virtual.
- *Context-awareness.* Students interact with the environment, and that interaction is governed by the context in which natural learning would take place. This includes synthesized contexts like gamification and thematic or story-driven settings (Huang, 2015).
- *Self-regulated learning.* The environment allows students to control their learning

progress. In more advanced cases, the system uses this information to adapt to future studies (Huang, 2015), a technology that was not available when the original list was compiled.

- *Seamless learning.* Allows students to control their own learning processes and progress as they move from place to place.
- *Learning community.* Can access networked content and services to enhance the interaction between students and teachers.

This list provides the constructivist basis for authentic experiences and learning opportunities. The experiences, context, meaning, and motivation, and the acquisition of the knowledge would be the learners' primary experience, and the technology supporting it would simply play a facilitative role (Hung et al., 2013; Huang & Springer-Verlag, 2016).

One of the most rapidly expanding technologies to support ubiquitous learning is wireless technology. Expansive, location-dependent connections were actively endorsed as one of the essential underpinnings of uLearning (Barbosa et al., 2008; Dey et al., 2010). Barbosa cited WiMAX, Wi-Fi, and Bluetooth as crucial elements of connectedness in 2011. That list has since grown to include ubiquitous 5G wireless access that allows algorithms to provide data using the "internet of things." Radiofrequency identification (RFID) is a low-power alternative for providing location data to a more extensive network in which positioning data can be used to upload information to users that is relevant to their current locations.

The endeavor to move ubiquitous computing to the worldwide stage has recently seen a huge advance, as the company SpaceX deployed Project Starlite, which is intended to put 12,000 satellites into orbit to provide high-speed internet to the entire planet (Mosher, 2019). These nodes for data transfer will provide yet-unseen quantities of data. Given the demand to process all this information, the technology and science behind big data processing may play a significant role in the future of ubiquitous learning. Later in this review, the roles of specific technologies will be addressed. The full range of technologies, new and old, will help uLearning realize the benefits that many researchers have reported from experiments.

In today's classroom, uLearning does not use live camera feeds to upload lessons to the cloud for everyone to access (Ogata et al., 2014). However, experiments in Taiwan and China have used intricate algorithms and RFID tags to provide lessons in parks and museums (Liu, 2007). While research has suggested a promising future, constructivist uLearning in classrooms is still confronted by restrictions. Access to technology and pedagogical freedom retard the evolution of uLearning-type systems. Connectedness and big data provide unique opportunities for the personalization of learning. However, the customization that some variants of uLearning thrive on could also pose security risks, as big data can impinge on personal freedoms (Laborda, 2015). In the section "uLearning Analyzed through Pedagogy," below, I give more attention to the current state of ubiquitous learning.

Ubiquitous Learning: Varied and Evolving

Ubiquitous learning is a new paradigm

However it still remains far from universal acceptance (Laborda, 2015). It was valued as an area of research to improve educational strategies using a wide range of established and experimental technologies (Barbosa et al., 2011; Lewis, 2010; Ogata &

Yano, 2009; El-Bishouty et al., 2010; Rogers et al., 2005; Yin et al., 2004; 2010). The revolution in ubiquitous learning is expanding due to the evolution of wireless networks and cellular networks and increasing access to the internet. Wong and Looi (2011) recognized this trend. They started to refer to the ability to learn anywhere in or out of the classroom as "seamless learning." The term "seamless" was meant to refer to the borderless transition between in-class and out-of-class learning (Hung et al., 2013). Before there was technology to accomplish this, the American College Personnel Association (1994) noted the importance of connecting classroom learners to the outside world. Doing so would result in greater academic success. As technology has advanced, the concepts of ubiquitous learning technologies have grown in kind.

Kidd and Chen (2011) claimed that personalized forms of learning "can be powerful, personal, current, and situated as learners and instructors can communicate, interact, and learn in real-time." They did not say whether this instructional communication must be face-to-face, but one can infer that as long as instructional communication can take place between the student and the instructional component of the lesson when needed, the real-time criteria can be met from the perspective of the student, who requires the right information to be available to for learning while minimizing time spent waiting for feedback.

Yang (2006) defined "context" from two perspectives, the students and the learning services. From the student's perspective, the context is the surrounding environment, including web services, discovery and access, the student's profiles and preferences, and the network channels and devices used to connect to the web. From the service's perspective, the context is the surrounding environment affecting the delivery of learning services, such as service profiles, networks, protocols for service binding, devices, and platforms. Typical services for ubiquitous learning are devices, network detection, location tracking, calendars, content access, and social activity services (Yang, 2006).

In *Ubiquitous Learning Environments and Technologies,* Hwang and Springer-Verlag (2016) discussed the context of the student in the uLearning design process. They emphasized the importance of the student's perspective. One's understanding of the learner's background and prior knowledge significantly influences the learning context's structure. Arguably this would include geographical and cultural experiences as well, though no acquired literature discussed cultural perspectives in conjunction with uLearning.

<u>Instruction within uLearning systems.</u> In answer to the questions, "What does the learner know about the topic or about associated topics?" and "What skills are fundamental to understanding the new topic?" temporal elements such as when the student was last taught the material or how much time passed between sessions on related topics? Additionally, the student's successes or failures could influence the student's motivation or momentum in moving through the material. That particular statement refers to the students' affective filter developed by Stephen Krashen's Affect Hypothesis (1992). Although one could add linguistic understanding of the content, I found no resources drawing links between language immersion, ELD students, or other language-related topics and uLearning.

Students have various learning perspectives, such as Gardner's eight learning styles, VARK (visual, aural, read/write, kinesthetic), and the Felder Silverman learning style model, which provides standardized answers of how students learn. The FSLSM provides delineations such as sensitive-intuitive, verbal, visual, sequential-global, and active-reflective (Felder & Silverman, 1998).

Beyond the psychological profiles, students' working memories are what Miller (1973) described as the limits that people can keep in short-term memory accurately. The number revealed in that study was 7 +/- 2. Working memory capacity (WMC) plays a key role in uLearning lesson design. The data were collected independently of the learners' style or profile. The methods for collecting those data from students were not divulged. However, the guiding limit is that no more than seven elements should occupy a student's cognitive pathways at any time during uLearning. Additional neurocognitive traits might include profiles generated for memory capacity, inductive reasoning, and associative skills. Hwang and Springer-Verlag (2016) discussed this aspect of the student's perspective when proposing how to make a road map for the integration and deployment of uLearning.

Tan et al. (2010) presented a uLearning framework in which five factors had to be in place for the technological aspects to be implemented:

- timing of the learning: day, year, or point in the curriculum,
- location of the learning and the student: classroom, park, museum, home, etc.,
- availability of devices or technology at the location,
- the content to be learned,
- the individual characteristics of the student: learning style, previous content exposure, etc.

Tan et al. (2010) described situations that might give further insight into these framework guidelines for uLearning. For example, the timing might matter to a law student who needs access to a legislative body but could be turned away because the uLearning system understands his location, environment, and, most importantly, his timing. If no legislative body is meeting at the time, the system must know to provide the right content in the context. The right content will give the student proper access to resources around them with which they can learn. Tan’s framework does not address how AR and VR would change these frameworks.

Timing and content are crucial, but the devices and their connectivity hardware are the uLearning framework's bottleneck and determine what the student can and cannot interact with or experience. For example, if a device doesn’t support Flash animations (as of 2020, nothing does), the student will be denied the ability to use that learning medium. The synchronization of the device, its access to the network, and its access to the server that provides the content are all interdependent. If any part of this system breaks underperforms, the entire uLearning framework is affected.

The student is the final and perhaps most complex variable in the framework. The technical complexities are numerous and may fall largely outside the control of the instructor. For example, instructors and content designers may have little on the institutional network or the networking variables controlling students’ access at home. In addition, the mental, emotional, and preparatory state of the student enters the equation. Putting students in a psychologically better state may not be something the instructor or the content design can do. Authors who have written on the application of uLearning, such as Huang Springer-Verlag (2016), have identified these external challenges to learning with technology-enriched environments.

However, learning styles may also be influenced by cultural norms. If a pool of learners contains wide diversity in culture, parental involvement, and socioeconomic status, creating a curriculum that fits all the students' cultural priorities may be challenging. Huang and Springer-Verlag appeared to conclude that the community's cultural profile can be considered one of the elements of contextual awareness. Questioning students before the learning activities to determine this presents a couple of possible drawbacks, however. The questioning might take up critical education time, and the information gained represents the student only at that particular time, place, and age; those could change the following day (Huang & Springer-Verlag, 2016). Bayesian networks were used to collect students' data as they experienced the content to illuminate points where intervention might be useful (Graf, Kinshuk & Liu, 2009). Ubiquitous technologies can help teachers make these determinations and analyze students' learning styles and patterns.

uLearning can be static and can happen where learning happens, essentially creating or engineering learning to happen when the student can best relate to the subject. Huang and Springer-Verlag (2016) called these contexts "authentic environments." The evolution of technology has led to more powerful and compact devices that can be used in the field and computers powerful enough to create worlds that students can be transported into for maximum collaboration with the learning environment, as in AR and VR systems. Integration between GPS and mobile cellular networks and positioning based on wireless antennas appear to be the beginning of such distributed systems (Hightower et al., 2006). The precision available today allows for practical applications (Vaughan-Nichols, 2009). Moreover, the proliferation of wireless hotspots suggests that this precision will grow in the future, allowing for sophisticated location-based services (Dey et al., 2010). As of 2020, the date of this literature review, SpaceX had created a global network of 4,425 satellites to provide complete planetary coverage for high-speed internet (Kyle, 2017). The argument could be made that these notions are outdated, considering the advances in global internet access made in the last ten years.

Beyond geographical location, various elements of the student's descriptive context and conditions (e.g., business location, temperature, humidity) could be included and detected, and sensing devices (e.g., RFID, GPS, or an infrared ray system) could be used in context-aware learning activities, or what Huang and Springer-Verlag (2016) called "environmental awareness." For example, RFID has a broadcast distance measured in feet and is useful for localized applications. GPS is suitable for detecting locations in large areas, as the GPS signal is global and free and requires only an app to use. Moreover, the contexts have an even more daunting task, as researchers have indicated that "timely location" is the most essential and fundamental parameter for context-aware uLearning (Chu, Hwang, & Tsai, 2010; Hwang et al., 2008).

It should be noted that nearly all uLearning environment and technology studies were done in clinically sealed environments that existed for experimental purposes only. Little uLearning research has been applied primarily to in vivo learning environments. For example, Hwang et al. (2018) conducted a study on situated uLearning on 52 fifth-grade students. There was no indication within the study if this research was done during the school year, after-school, or done in a special session where the students happened to be gathered. No attention was given to the students' external life-experiences over the four-week instructional period. Additionally, the subjects were divided up by achievement level from the previous semester's learning achievement levels. The psychological implications on the students' outside-school experiences as well as the stress induced by suddenly changing the students into high and low groups was not discussed. The only mention of "real-world applications" was in reference to the curriculum, which by uLearning definition, has to be connected to the students' real-world experiences. Many of the studies involving students within uLearning environments ignored these external factors and promoted a clinical setting where messy real-life variables are ignored or are assumed to be negligible. (Hwang et al., 2012; Shih, Kuo, & Lui, 2012; Ogata & Yano, 2009, 2004; Hung et al., 2013).

uLearning presents a variety of problems, and the technology needed to solve them has changed drastically since the inception of the idea in 1993. The premises of uLearning include having the right information at the right time, where it can be applied to the real world in a meaningful way. The delivery of that has required the synthesis of technologies that continue to evolve. The growth of wireless devices in both power and number has created great potential for uLearning. However, mobile devices' use does not imply that uLearning is either a form of mobile learning or a part of the eLearning paradigm. There are commonalities, but these concepts are not the same.

Large numbers of people create large quantities of information, whether they are aware of it or not. Comments, "likes," time in-session, and even the inclusion of meta-data in material consumed online can be used to generate a picture of small pieces of collectible information. When this lake of information is dammed up and processed, striking correlations and predictors can be presented (Huang & Springer-Verlag, 2016).

The graphical evaluation of massive pools of information tools like the structural equation model (SEM) can be used to show the connectedness among variables used in social-science behavioral analysis. SEM analysis can indicate that a causal relationship is in play (MacCallum & Austin, 2000). SEM can also be deployed in a counterfactual manner: an SEM analysis can suggest a significant correlation to something claimed to be true but also present big-data statistical analyses demonstrating the claims to be likely false. SEM can show that there is a non-causal relationship and a causal one. Analytical tools, such as SEM, provide insights into what students know and have proven they know and into what they claim to know and do not. More robust versions of SEM may even provide students with opportunities to converse with an assessment A.I. that can determine that can accurately estimate the depth of their knowledge through the content of the talk.

Future uLearning enhancements

Big data analysis presents the learning technology community with the highest anticipated possibilities of uLearning. With new options comes the development of innovative tools that can use learning analytics to enhance what many consider the "holy grail" of content absorption and learning efficiency. Huang et al. (2015) described the factors of learning efficiency as a complex commingling of learning style, metacognitive scaffolding, peer interaction, self-regulation, coregulation, social networking, and biological stability factors such as emotional and hormonal status at the time. These learner-dependent factors are then factored into the presentation of content and what was noted as "support for learning" elements. These variables included pedagogical effectiveness, peer evaluation, instructional interface, human factor design, instructional design, presence and type of learning props or objects, assessment structures or options, instructional flexibility, and instructional choice. All of these depended on the instruction being human or software mediated and the connection between the student and the method of content delivery. For example, Mouri et al. (2016) used spatio-temporal data-mining technology used in disaster and weather prediction to build uLearning tools for language instruction. Phrase recognition was developed using the associations among phrases used by participants, such as where and when these phrases were used (via GPS data). For example, thousands of “good mornings” uttered at workplaces in the morning would intuitively be used by the AI as an appropriate phrase for that time of day.

Zimmerman and Bandura (1994) suggested that this type of computational intervention would fall in line with the kind of educational reforms that the U.S. has been pushing for the last fifty years. The notion of a learner as reactive instead of active and as a recipient of information rather than someone seeking and acquiring it may not have been realistic, though an argument could be made that in 2020, the expected roles are opposite to those of the original prediction. The vast amounts of information available seem to have put the student in the position more of a gatherer than of a hunter.

uLearning is not merely another form of distance learning. Although uLearning could be done at a distance, the one-dimensional nature of traditional distance learning is frequently cited as a source of disengagement. Moreover, the discussions' asynchronous nature has required students to engage with each other separately, frequently, and in ways that minimally meet course requirements (Erickson, 2013). Advances in mobile education hardware and software are opening more doors to distance learning and transitioning students to the uLearning collective. These technologies address the need for interaction and the fact that learning often takes place independently (Laborda, 2015). Key researchers in this area (Hwang et al., 2008; Ogata et al., 2008; Song et al., 2010) have all described pedagogical enhancements of peer interaction and recommended support for learning in authentic situations, for self-regulated learning, and for the active deployment of personalized services as benefits. The potential of uLearning echoes throughout the literature, yet the focus always falls on its technological potential and less on how the technology is deployed.

Ubiquitous situated reflective learning (USLR) was also suggested as an option for uLearning applications. Situated reflective learning descends from works by Collins (1994) and the self-regulated learning theory developed by Zimmerman and Schunk (1989). This model was designed for situated learning and had distinct areas of application towards uLearning environments. It has five steps, summarized in Table 1.

Table 1 Steps for Situated Learning

Steps in the Process	Description of the Purpose and Support for Each
Articulation step	
Purpose:	Student thinks about learning and then judges and classifies.
Supporting functions:	Teachers have explanatory functions.
Authentic step	
Purpose:	Student discovers connections in knowledge gained from real-life situations.
Supporting function:	Learning annotation, GPS, situated triggers, photography, and sound recording (all aspects of learning to interact with the electronic learning materials).
Evaluation step	
Purpose:	Student reflects on the correctness of knowledge discussed with other students.
Supporting function:	Learning annotation, reflective learning, photography, and sound collection with others.
Plan step	
Purpose:	Student reflects to confirm errors in concepts and reestablishes a plan to learn correct information.
Supporting function:	Learning annotation and reflection.
Adaptation step	
Purpose:	Student confirms the reason for failed learning in order to covert plans into action.
Supporting function:	Learning annotation and reflective learning.

From a philosophical standpoint, uLearning is opposed to a teacher-centered approach and leans heavily toward a constructivist instructional design. Opportunities for uLearning are evaluated on the basis of their potential to support interactive learner-centered instruction (Kidd & Chen, 2011). Researchers in this area all appear to understand that to adopt uLearning, a teacher must embrace an entirely new role as a facilitator and not a sole source of knowledge for students. Moreover, the students will need to learn that uLearning environments are not merely about the acquisition of data but about how to organize and apply that data in the world they live in (Erikson, 2013). Interestingly, no literature was found discussing temporal applications of such learning activities.

Huang et al. (2012) developed another instructional design implementation tool that used uLearning technology to measure students' learning. MUKS is a semi-automated system for helping students complete a sort of matrix grid or a mind map. In essence, the students engage in "authentic activities" involving the identification of butterflies in the wild. The unit was developed around a specific garden in one of the Taiwanese elementary schools. The garden was divided into eleven areas, and the butterflies stayed in their designated areas due to the specific types of plants each needed for nourishment. RFID tags and hand-held PDAs were used to record information about each butterfly and its unique qualities. Both groups were given access to uLearning technology; the experimental group used the MUKS template to organize their work. The researchers noted a tendency toward confusion with the uLearning system among the non-MUKS students. They concluded that a "pure" uLearning environment would often confuse students, and they would stop and need redirection during lessons.

The MUKS instructional approach also included a protocol for structured collaboration, in which students compared their grids (mindtools) with each other. The students in the "pure" uLearning environment were given the opportunity to collaborate but no overt guidance on how to do so. The lack of structure encouraged more off-task behavior and social loafing. The t-scores from the statistical analysis demonstrated that the control group consistently scored lower than the group that used the MUKS construct.

A couple of observations can be made about this experiment. First, the idea of structural guidance seems to undermine the premise of uLearning. If the experiment had been done with older students, it would be hard to even recognize it as uLearning. The ubiquitous use of sensor technology and handheld devices was a complex deployment of uLearning technology, as was the introduction of data to students when they were physically present with the object of study. But other researchers in the field might have difficulty calling this a substantial step toward uLearning; it seems rather like a step back toward more regimented learning if viewed independently of the psychological and behavioral limitations of younger students.

Although students' task freedom might be brought into question, the butterfly experiment does provide an example of legitimate location-accurate context-aware services. The first approach involves filling in a form (digital or paper) and acquiring environmental context directly from students' input. The second acquires context awareness through sensing, recording, and positioning systems such as GPS (large environments), RFID, and sensor networks (small, enclosed environments). The third approach is context extraction, which involves deriving contextual information from students' ontological and phenomenological presentation of their experiences, either in person or through uLearning technology (Huang et al. 2013), such as VR and AR, though there was no specific mention of these tools.

On the other end of the age spectrum, Yang (2006) conducted an investigation in which a uLearning environment was engineered to identify the right learning collaborators, learning contents, and learning services in a university context. The system would use the position, time, date, and profile of the student to provide intuitive data that could be used for learning. It was supposed to match the needs of the student to the real-time availability of those resources. In this situation, context and environmental data provided the most needed information. When the user logged into the network, the server would determine the type of device, the user's profile on that device, and the user's physical location. Additional information about the user was derived from calendars, and personal profile information in a process called context wrapping (Yang, 2006). The network server handled the communication, but each user acted as a node. In this sense, the user functioned as a server. For example, suppose someone asked for the location of a study group. Network users would sort this request on the basis of their knowledge of the world around them and provide feedback to the requester. This open, peer-to-peer format would be ideal for organized, technically savvy, and self-motivated students, but elementary and middle school students may not have these traits. This example is one of the purest forms of uLearning environment, one where the learning is governed almost entirely by the user and peers associated with the network.

Yang also identified several problems with the system. One was its ability to validate the information. The system had no mechanism for verifying dates, times, locations, or other data transferred between peers. Perhaps more importantly to users, it was not possible to see whether anyone else was online or nearby. Requests would be sent out and go unanswered until the system timed-out and deleted the message. The article reported an anecdote was reported about a man, Albert, who wanted to have a real-time discussion about the New York Yankees. He was unable to search for or identify anyone he knew who was online and could communicate in a system-sponsored chat room. Instead, Albert left a post-it-note-style link to see if anyone was interested in future discussions (Yang, 2006).

Low-tech uLearning adaptations were also considered paradigm inclusive and not to be denied due to the lack of high-cost infrastructure. Searches using the terms "paper-based ubiquitous learning" and "low-tech ubiquitous learning" revealed little. For the first, search engines returned articles on paper and ubiquitous environments in health care, with a note reading, "Your initial search query did not yield any results." The search for low-tech ubiquitous learning produced the same result.

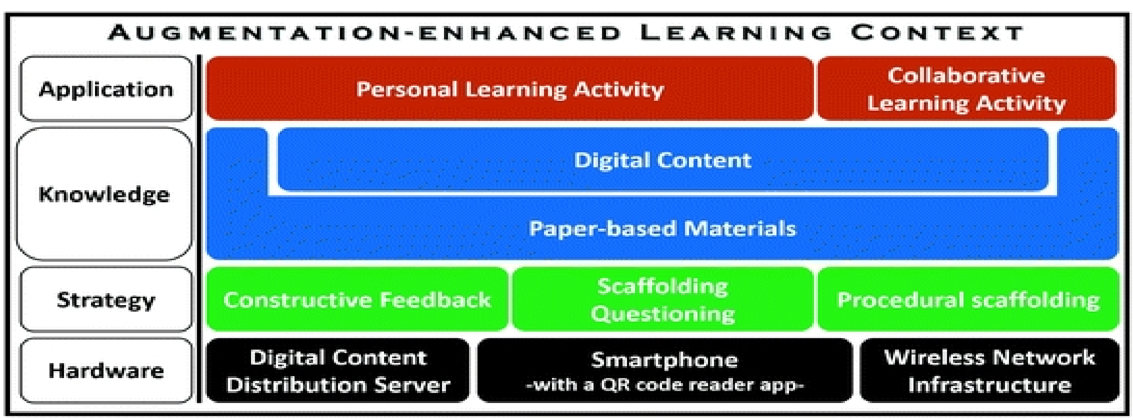
However, there was one book that covered the problem in some depth. Huang and Huang (2016) dedicated an entire chapter to the idea of low-tech uLearning environments. These systems are built on procedural scaffolding, in which uLearning deployment is much more confining than in typical uLearning environments. This was done to organize student engagement, maximize results, and reduce social loafing (Janssen et al., 2007; Johnson & Johnson, 1989). According to Chen et al. (2011) and Pea (2004), the additional scaffolding provides increased opportunities for collaborative learning and significant learning efficiency increases. In summary, the paper may be the structural organizer of the learning, but the technology provides the ubiquitousness of the learning environment.

Huang described the application of low-tech or paper-based learning environments as having four layers. These are described in Table 2. A visual interpretation is provided in Table 3 (Huang & Springer-Verlag, 2016).

Table 2 Low-Tech uLearning Applications

Step	Associated Actions
Application	The personal learning activity or collaborative activity
Knowledge	The digital content supported by the paper-based materials
Strategy	Constructive feedback, scaffolding, questioning, and procedural scaffolding
Hardware	Digital content servers, student-usable digital tools, connective network technology

Table 3 Augmentation-Enhanced Learning Context



Learning materials can be placed in front of students through any number of mobile devices. Mobile device flexibility tends to put the burden of distribution on devices such as cell phones, iPads, and others that allow students to acquire content from places other than a desk in a classroom (Embong et al., 2012; Koike et al., 2001; Rockinson-Szapkiw et al., 2013). Since these studies were published, many high schools have begun using Chromebooks as tools for acquiring content in order to embrace more ubiquitous pedagogies (Doyle, 2015). These devices not only add value to the content, but they also augment texts to provide access for students with vision difficulties through zooming features, screen captures, and text-to-speech functions (Chen et al., 2011; Koike et al., 2001). Digital devices also provided enhanced constructivist pedagogical options when students were online. Quick feedback between the content provider and the student is a cornerstone of heuristic constructivist instructional styles (Vygotsky, 1978; Hannafin et al., 1999; Saye & Brush, 2002).

Ubiquitous learning is a constructivist pedagogy, and through that lens, Huang and Springer-Verlag (2016) suggested that a paper-based uLearning system could be built in several ways.

Possibility 1: Self-learning with constructive feedback. The student accesses the material through whatever digital tool is available, interacts with the content, follows the scaffolding, and then submits the learning product for evaluation. The self-grading parts of the system can be set to allow retakes, and various types of questions can be used to vary the assessments.

Possibility 2: Self-learning with scaffolding questioning. The student is provided with supportive questioning. QR codes, sounds, and information icons provide direction and guidance. Incorrect responses on assessments prompt the student to go back and re-study the section containing the answer. According to Chen et al. (2011), this method was particularly useful for teaching Taiwanese English-language learners.

Possibility 3: Collaborative learning with procedural scaffolding. QR codes on printed material provide logins, and QR codes on paper provide access to digital materials. QR codes are used to initiate team discussions, and after a set decoding process, team members respond to questions. Experimental results suggested that the procedural scaffolding team produced better results than those who worked individually (Huang et al., 2012).

After assessing the commonalities between them, researchers had to contribute to the topic of low-tech versus paper-based uLearning options. A few criteria were clear: the need for carefully planned activities and a process that students could follow was urgent, and informational scaffolding would also play a critical role in the success of the learning activities. Instructional designers must anticipate the informational needs of students before implementing a learning environment, or be able to adjust it quickly enough not to slow the momentum of the learning experience.

Thematically situated learning takes advantage of a “brain hack” noted by Medina (2011). Under the assumption that knowledge is anything that can be recalled on demand, memory plays a vital role in learning. Emotional responses and intensity also play a crucial role in the neurochemical storage of memories, according to Medina (2011). Researchers have contributed to the understanding of the establishment of thematic uLearning environments. Their criteria include descriptors like the following:

- Active
- Constructive
- Cooperative
- Authentic

- Intentional
- Emotionally guided
- Integrated

Ubiquitous learning appears to be the primary vehicle for learning when one needs to accomplish two critical objectives: Apply the teaching in a real-life context, and provide essential data when information is demanded. When a narrative or storyline is applied to a hypothetical timeline of events, educational content designers can meet both objectives and also create a structure and pacing (scaffolding) to govern when, where, why, and how content is delivered.

For example, learning about the rainforest ecology through a mobile app can meet one of those goals. When coupled with cellular technology, RFID, and other sensor technology, environments like museums, zoos, and nature preserves can provide need-driven connections to relevant information (Chang & Chang, 2006) and their own thematically situated learning experiences. Museums and outside environments are inherently thematic and emotionally relevant vehicles.

A storyline, linear or nonlinear, provides educational content designers with control over story-based events, content for the learner to choose from, choices for interacting with objects, and ways for those choices to interact with the story. Huang et al. (2015) described the construction of partial ubiquitous knowledge structures that similarly relate objects to specific bits of information in ways that provide feedback relative to the user's position in the game. For example, a scientist NPC might present one set of data to a player early on in the game, but in a different location further along, the timeline might provide a very different set of data. In the context of learning, partially ubiquitous knowledge structures could play a significant role in students' experiences in specific learning environments.

Situated or theme-based learning can be enhanced in natural settings like parks or ecological reserves, as Lui (2007) did. In their study, RFID technology was used with a "treasure hunt" theme. The study involved two classes of Taiwanese elementary school students. ANCOVA results for the tests of experimental group ($F = 18.89$, $p < .005$, $d = 2.01$) indicated a significant difference from the control group. Each additional phase, including a problem-solving section and an immersive learning activity, showed that the use of the thematic uLearning helped students to retain and make use of the information they learned.

Moreover, advanced technology was also used to augment the appearance of birds that were not present due to seasonal migration. Rudimentary augmented-reality (AR) technology was used to show where the birds would be and what they would look like. Lui's (2007) study appears to have been successfully integrated into the situational context and a thematic framework that provided evidence of the efficiency and efficacy of uLearning.

The gameplay aspect of uLearning is highlighted when one adds a plot sequence and emotionally relevant, context-arranged relationships. A common way to motivate someone to take part in a game or contest is to present a "rescue" theme as motivation. Adding team members who either play along or act as non-player characters (NPCs) can help the player progress through the story (Rabin, 2010). This approach can be seen in the 2017 film *Jumanji: Welcome to the Jungle*. In it, players of a game learn about jungle life, animals, and the environment on-demand to let them progress in the storyline.

Multiplayer interaction and NPCs provide direction, assistance, and “just-in-time” knowledge relevant to the situation at hand. The NPCs' inflexible nature and specificity are mocked in the movie to demonstrate the role they play in the story progression. Relational connections provide ways for players to use non-quantifiable motivation factors (not grades, scores, etc.) to continue playing. Interestingly, the same relational and emotional connections include one of the three main aspects of successful instructional dyads (Vygotsky, 1974).

Huang et al.(2015) discussed the generation of ubiquitous learning activities through a series of steps, shown in Table 4.

Table 4 Steps for uLearning Activities

Step	Actions
Analysis of the learning domain	Determine the relationships between the objects and the characters. Once that is done, the knowledge structure for the environment is used to generate the section attributes.
Roles and themes	Options for the learners and instructor to work within.
Learning activity chain generation	Puts the role and theme into every activity that the activity engine determines is suitable for the situation, theme, or character. The engine then produces the chain of learning activities by comparing the complexity and rarity of learning objects in the environment.
Learning by playing	Users follow the instructions and look for designated learning objects (icons or real-world objects that represent specific content-based data). Players learn by playing heuristically, experiencing the cause-and-effect aspect of being present in that world.
Personal experience updates	Experiences and measured knowledge are kept in a database, so the game's engine is aware of the player's progress and performance. Lu et al. (2011) provided information on the mechanism of autonomous content generation, but it extends beyond the scope of this literature review.
Basic story application	The most basic iteration is in a traditional

classroom but masked as a more sophisticated environment. Context-aware story engines take the ubiquitous knowledge structures and then build a story structure in line with a selected genre and use it to sprinkle thematic elements into and around the generated learning activities.

Citing experiments involving male and female students, Huang & Springer-Verlag (2016) described how engagement could be measured in role-playing educational games that were situational in design:

- Stories influenced users to accept the RPG context.
- Stories made the RPG feel useful but also seemed to reduce the perceived efficiency of the learning process.
- Descriptive statistics showed that males and females both had positive perceptions of the experience effectiveness of the RGP storyline. However, females perceived this at a higher rate. Huang et al. (2015) mentioned that other researchers of RPG learning reached similar results.
- "Hardcore" gamers (people who played video games more than 20 hours a week) were more positive about the RPG experience than casual gamers.

The inclusion of a complete, progressive storyline was one of the more apparent factors in a successful uLearning experience. Huang (2016) noted that four-phase transitioned learners produced successful uLearning results.

In RPGs, the *teleport phase* is the beginning of the process, when the environment is presented to the player, and the game offers them an array of visuals to prepare them for the *transfer phase*. In this second phase, the player takes responsibility for driving the experience. The *training phase* follows, ensuring that the player is properly instructed in the rules of the environment and the control mechanics. *Challenge phases* make up the majority of the experience and provide "bread crumbs" that ultimately make up the *adventure phase*. This last phase is the collection of all of the previous experiences, which eventually lead to a penultimate experience that is usually presented as an ill-structured mystery or an open-ended challenge.

Many educational researchers have emphasized the necessity of "authentic activities" for learning to take place effectively (Collins, 1991; Looi et al., 2010; Price & Rogers, 2004). This neatly sums up the concept of situated learning. It also opens new avenues of expression that can be found in augmented and virtual reality. Huang and Springer-Verlag (2016) made identified science as a subject area in which storylines have been particularly useful.

Situated learning stresses the role of context. According to this approach, learning includes the situation in which it occurs (Brown et al., 1989; Hou, 2011) and within which the content is presented. That could be another location or another type of reality. The literature is not clear on the type of location or reality, virtual or otherwise.

Analyzing Student Experiences in Ubiquitous Environments

uLearning environments are fluid and free-flowing and meant to mimic the real world and react to the needs of the learner. The analysis of data collected form these environments come from a variety of different sources, yet appear to have several qualities in common. Like most educational studies that test a means of improved educational content delivery, acquisition of performance data related to how much information the student learned tends to be consistent (Chen & Lin, 2016; Chang &

Chang 2006). Also common to many educational technology studies are the perceptions of those involved in the study. Hwang and Springer-Verlag (2016) argued that the student's perspective of the uLearning experience was of high importance and understanding the students psychological influences were paramount to more clearly understanding the interaction between the learning system and those using it. Chen & Lin (2014) performed a study using fifth-grade students in Taiwan where a context-aware uLearning system was used to instruct students in astronomy. It used a mix-methods approach where both assessment scores and a phenomenological analysis was completed with the students to assess their lived experiences. Figure 2 illustrates the flow chart of behavior influences the uLearning system variables that formed the collective experiences of the fifth-grade students.

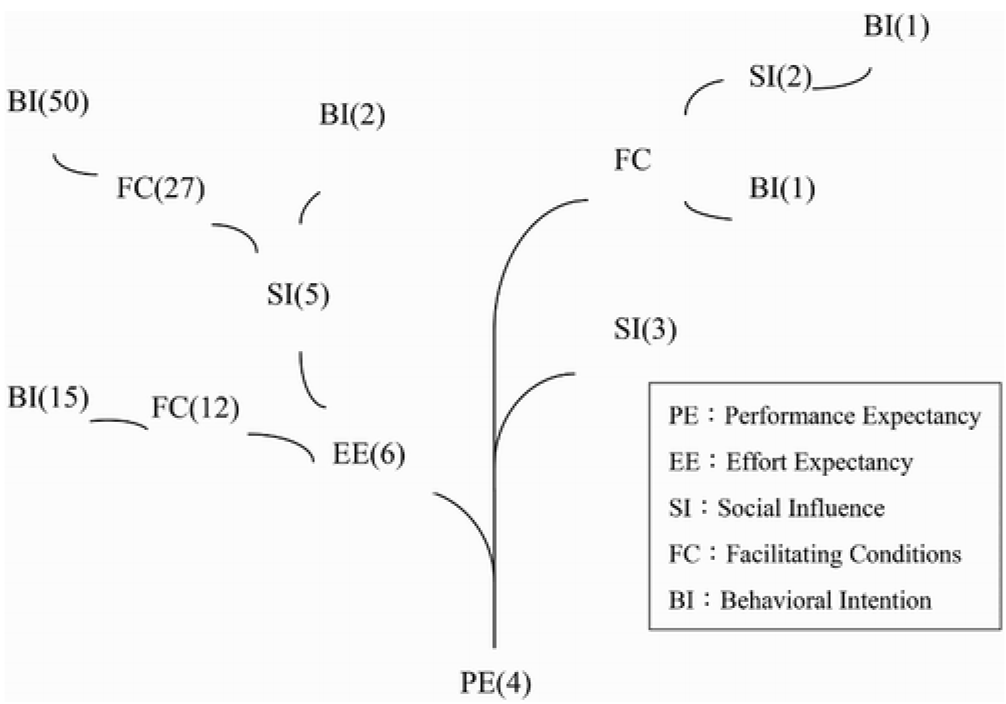


Figure 2 The tree of perspectives of uLearning from Chen & Lin (2016)

The “PE” at the bottom of the figure represents the performance expectancy of the students. Expectancy in this case refers to the users sense of confidence and their expectation that they will be successful. Note that the PE is comprised of a variety of other variables that reflect both factors surrounding the students personal perceptions as well as factors surrounding the uLearning system (FC).

The analysis of uLearning systems also include another data variable that incorporates the metadata of the users experience. This data typically includes factors such as network traffic, user login frequencies and duration, types and volumes of media downloaded, number of conversational interchanges between users, and possibly any sort of progress if the uLearning experience has a linear component. Erickson (2013) incorporated user tracking data in an article that stressed optimal times for system updates when designing for pedagogical purposes. Huang and Springer-Verlag (2016) and Hwang et al. (2018) supported the idea of collecting vast amount of backend metadata and apply that information to big data-type statistical analysis to acquire predictive information about system users. The data would serve as a way to help predict the needs of the system’s users before the demand became too diverse or intense for the system to manage properly. In an entirely different application, Jeng et al. (2010) used backend network data and GPS coordinates to facilitate a uLearning system that would aggregate mobile study groups for students based on the students’ login locations. Ubiquitous systems attempt to address complicated and varied learning environments. The literature suggests that there are very few if any that are identical. By their nature, uLearning addresses the needs of the learner in the learner’s world. As such, the large variance of data that is collected when studying these environments would appear to be a necessary function to better understanding how learners interact with them.

Affective Filter Hypothesis

Dr. Stephen Krashen first postulated the concept that student could actively "filter" out information on the pretense of personal bias. Krashen's work has been subject to repeated scrutiny over the years since the idea's inception in 1988. (Krashen, 1998). According to the theory, factors such as motivation, attitude, and anxiety directly impact foreign language acquisition. Further studies by Lin (2007) and again by Lin, Chao, and Huang (2015) would suggest the Affective Filter Hypothesis, or more commonly known as the "Affective Filter," applies to other areas of study besides language.

The affective filter, though classically intended for language learning, could be applicable to any subject. The term "Affect" is often used in educational literature as the term that defines the emotional and cognitive biases of the learner in a given learning environment or situation. Trujillo and Tanner (2014) make this point in a paper called "Considering the Role of Affect in Learning: Monitoring Students' Self-Efficacy, Sense of Belonging, and Science Identity." The article begins with painting the picture of walking into a high school biology lab for the first time. This compelling image recalls the various emotional reactions that one has when walking into a new, potentially off-putting, or exciting setting. In 2012 the National Research Council initiated a national call into research that explored the affective domain to better understand students' affective experiences. Neuroscientists were also increasingly exploring the symbolic relationship between cognition and affect. Vermunt (1996) put it this way, "Our focus here, affective learning, is described as those activities directed at coping with the feelings that arise during learning, … [leading] to an emotional state that may positively, neutrally or negatively affect the progression of a learning process" (p. 26).

The affective filter, the affective domain, and the connection to self-efficacy – or more to the point self-expectancy – stems from Bandura's work in 1997. Albert Bandura established much about what the educational community knows about a learner's self-perceptions of their abilities. Before there was an Affective Filter Hypothesis, Bandura had already begun to identify the importance of self-efficacy in the areas of counseling psychology, occupation functioning, school experience, program performance, and programmatic outcomes. Additionally, Trujillo and Tanner (2014) as well as Usher and Pajares (2008), also noted the concept of non-transference of domain-specific areas of confidence. Despite the relatedness of two particular disciplines, the sense of self-efficacy does not automatically transfer. It may, but that relocation of confidence is not guaranteed. As noted by proponents of Expectancy Theory, the ability to develop actionable skills in a specific area may be connected to more than one's confidence in a particular content area.

Summary

This literature review revealed a fundamental incongruency between Hispanic multi-active behaviors and the expectations of U.S. public schools. The modern, progressive school system advanced by John Dewey would engage students in focused, linear, and productive education. This system, which Dewey's influences Immanuel Kant and Karl Marx would probably have approved of, became the dominant educational framework in 1837 (Cohen, 1979). Because most of the population had linear-active psycho-social behaviors, the educational system was fairly homogenous at that time. As the Hispanic population grew, it presented a problem, however. According to the 2007 census, Hispanics' median annual income was almost $14,000 less than that of Whites of similar socioeconomic status. In addition, only 57% of Hispanics 25 and older had graduated from high school, and only 11% had a bachelor's degree (United States Census Bureau, 2006). Moreover, these numbers have been declining for decades.

Teachers of STEM subjects noted this behavior as well. They related how students would do baffling things that undermined their education and made no sense to the college-educated, mostly Anglo-American teaching staff. No teacher at the informal pre-data-collection gathering had ever heard of the Lewis cultural framework. However, they all saw the similarities between the traditional school systems and linear-active psychology. Anecdotal evidence suggested that an overwhelming percentage of teachers that also saw the psycho-social immiscibility. They also had no ideas about making the situation better than giving students more time on assignments.

The lack of relevant Hispanic pedagogy may be a result of state-mandated spending. Wenglinsky (2012) pointed out that districts may legally have no choice on how to spend Title I money, which is supposed to offset the financial discrepancies created by property tax-based funding. Wenglinsky pointed out that little money was spent on training, and it was not spent on expert instructors but on staff who had some expertise in the area.

Ubiquitous learning was a pipe dream even fifteen years ago. However, developments in network and mobile device technology have opened the door for it, and it has been tested successfully in several countries. This study places considerable importance on cultural frameworks and the role they play in academic success. It would be a mistake not to address any culturally influenced behaviors that might affect the studies' outcomes. Most research in this area has been done in China, Japan, and Taiwan; Hwang et al. (2018) is a representative instance.

The uLearning system *AREA154: Apocalypse Division* in this study was based on longstanding lore of black sites, secret bases, and special-access programs the U.S. government keeps confidential. Whether this lore is accurate is irrelevant to the validity of the students' perceptions. The curriculum includes five "case files" involving STEM-based tools that would help a person survive a world-altering event like the Yellowstone super volcano's eruption. In the next chapter, the specific research methodological lens of grounded theory is discussed in detail and reasons for selecting GT as the investigative lens. Grounded theory methodology has a history of great variation within the lens and often is looked at as being overly simply or far too complex and lacking a more exacting methodology. These challenges to the rationale and application of the Grounded Theory method used in this study including visualizations that will show that the data in this study is, as Glasser put it, "a theory grounded in data." Discussion on the application of GT, information on the participant selection process, data collection process, and analysis are presented in chapter three.

METHODOLOGY

According to the United States Census and the California Department of Education, Hispanic populations in U.S. public schools struggle academically more than any other minority group (Haile & Nguyen, 2008; Hawley et al., 2007; Morales & Saenz, 2007; Neufeld et al., 2006; Schwartz & Stiefel, 2006). The U.S. Government included specific mandates in the No Child Left Behind Act of 2001 (NCLB; United States Census Bureau, 2006). Lewis (2010) presented the results of a 26-year study that offered a way to categorize peoples' collective behavioral traits from different countries. This model provided insights into the psycho-social incompatibility of U.S. schools and Hispanic people. This study aimed to investigate the effect of uLearning design principles on students who demonstrate multi-active cultural behavior traits to devise a working theory governing the AREA154 program's noted successes.

Research Methodology

Grounded theory offers a unique lens to think about phenomena that contain ontological, epistemological, and theoretical assumptions linking research goals, methods, and analysis (Denzin & Lincoln, 2005; Thornberg & Chamaz, 2014). The large philosophical brushstrokes guide positivist or constructivist paradigms but require more refining to posit guidance for developing firm steps throughout a grounded theory investigation. In other words, it is the responsibility of each GT study to utilize specific steps that make sense for the research and the lens. Strauss and Corbin (1990) and Glasser and Strauss (1967) provided additional, more specific ladder-like stages for implementing grounded theory in an investigation. This investigation involves the impact of psycho-social processes on STEM cognition and expectancy in that cognition focused on seeking a mechanism, a theory, for observed performance improvements seen by the students who lived the experience. The social processes must be identified (Glasser & Strauss, 1967). However, as the investigator also plays a crucial role in the participants' experiences with the AREA154 program, the researcher's active role in the study must also be included (Strauss & Corbin, 1990). For that reason, the two schools of thought had to be combined to create the research framework for this study. Table 5 identifies the steps used in this study and the GT experts from which they were derived.

Table 5 Theoretical influences for study methodology

Framework stage	Glaser & Strauss	Strauss & Corbin
Starts with a general idea of where to begin (some prior research or observation has been done).	X	X
Uses structured questions, possibly followed by natural lines of questioning.	X	X
Conceptual description of situations under investigation.		X
Development of theoretical sensitivity (the ability to derive relationships) from immersion in the data.	X	
Theory is built by data and then interpreted by the observer.	X	X
Basic social processes should be identified.	X	
The researcher is active.		X
Data are structured to reveal the theory.		X
Coding and continuous comparison of the data enable patterns to emerge.	X	

Two coding phases are used to develop concepts that explain the phenomena: simple (breaking data down into small segments and grouping them to capture patterns in the data) and substantive (open or selective choosing of a core category and relating other categories to it to explore emergent patterns).	X	
The qualitative data reveal the validity and any correlation to the original hypotheses.		X

(*Qualitative Research: Grounded Theory: What is it?* 2019)

The investigation's goal was to develop a theory about the confidence building experiences observed within the uLearning environments. Grounded Theory should adequately guide the research methodology, as it was ideally suited to investigating relationships, developing meanings, identifying motivations, and capturing a wide range of facts about the environment and experiences of that reality (Prigol & Behrens, 2019). GT also promotes axiology and axial coding, including the subjects' central belief systems and behavioral psychologies. The exposition of fundamental beliefs can help identify motivations and reveal new connections between behaviors or interactions (Creswell, 2017).

The GT framework presented by Charmaz (2006) describes the researcher's role as a theoretical constructivist who constructs truth through cyclical data analysis. The emphasis is on the construction of meaning between individuals and the research environment and as new data emerges it, too, is filtered back through the data, tested against any evolving theories in a cycle-like manner. The research was conducted through an iterative exchange between the data, the data organization, and the cross-checking of new findings with continued observations. This process is reflected in Figure 3, where selective magnitude coding of categories was accomplished by cycling the newly emerged categories back through the data pool. Every category developed due to open and focused coding (cyclical area in blue) was then fed back through the cycle, where it was continuously compared to each of the 19 subjects' interview responses on that topic. The focus coding cycle produced 20 categories from Phases I-IV. Each category was cycled back through the process and compared against interview data to compare subjects’ experience data. Cyclical GT methodology played a significant role in developing rigorously analyzed data.

In an effort to further clarify the use of GT methods within this investigation, Figure 3 provides a simple outline that reflects fundamental GT methods established by Strauss and Corbin in 1990. The chart demonstrates that there was no initial guiding framework in the pre-research stage. The frameworks of uLearning and those describing the environment's social constructs were part of the AREA154 design philosophy before the study began. These frameworks were discovered after the program building process began and incorporated as guiding design principles for the duration of the two-year development period. As such, they are now variables for consideration while seeking a theory about Hispanic students’ observed success with this STEM subject. Figure 3 illustrates the methodology for data collection, analysis, cross-checking, cyclical analysis, and questions that promoted further cyclical investigation. A far more descriptive version of the GT methods used and how they were used can be found in Appendix H, where the application of theoretical constructs was illustrated.

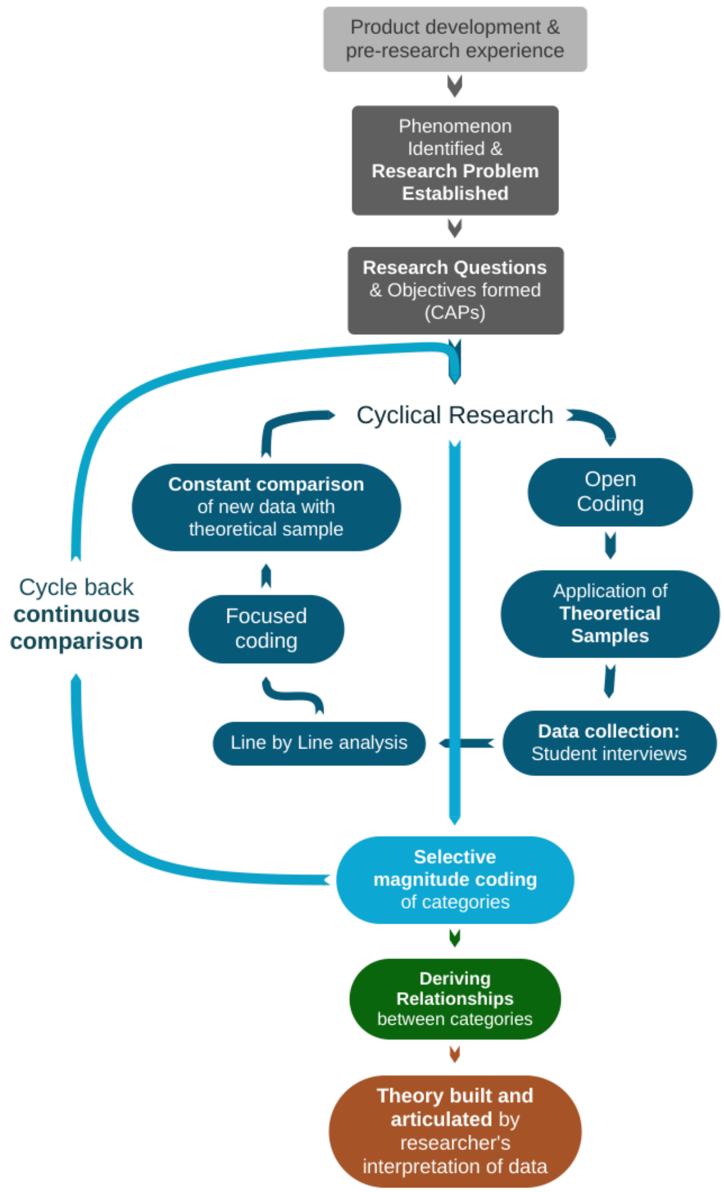


Figure 3 Simplified procedural flow chart of GT methodology

Note: Product development and pre-research experience (top grey section) represented two years of GT-like heuristic program design work. It was during this time of development that a sample framework called ubiquitous learning was discovered. It best described the system that was taking shape and provided guidance for new site features. The framework explaining the psycho-social aspects of the students' behaviors in class and out of class behaviors was discovered and incorporated as part of AREA154's overall design philosophy. In GT theory, theoretical samples help explain the evidence as it becomes known to the researcher. GT researchers typically do not have pre-existing frameworks before the study. GT practitioners usually avoid these situations as they can cloud the researcher's ability to see the data free of any filters. However, these frameworks were not known before the AREA154's construction and were discovered as a consequence of research *occurring concurrently* with the program's development phase. Once the phenomenon of student improvement was observed, these frameworks became critical parts of the phenomenon under investigation and were not pre-existing frameworks.

GT is exploratory and the researcher must be familiar with the environment, if not part of it (Charmaz, 2006; Creswell, 2017). These conditions contributed towards the inclusion of GT as an ideal qualitative lens, as the researcher had occupied the same physical space during the students' experiences with the uLearning environment (*Area154: Apocalypse Division*). Charmaz makes the case that the researcher can refine, intensify, and make sense of collected data, which are amalgamations of subject data and the researcher's observations of that data (Morin, 2005). The process sounds complicated, but Prigol and Behrend (2019) made a case for the use of GT in education because of this: education is also complicated and full of systemic, instructional, cultural, psychological, and technological difficulties. In Figure 3, (above) the blue and red sections (deriving relationships and theory building) GT supports the use of the researcher's intuitive understanding of the subjects, the unique environment, the application of the technology to evaluate collected data and produce findings reflecting true situational ontology. The inclusion of the researchers' situational familiarity was the primary reason GT was the most suitable choice for this study. Removing the instructor or the system designer from the equation would have been impossible. GT not only has procedural inclusion of this situation but encourages it (Strauss & Corbin, 1990).

Like many qualitative lenses, Grounded Theory has difficulty answering the question, "How much data is enough?" The problem of saturation varies between studies and tends to be asked when the researcher feels that the data are becoming redundant (Charmaz, 2006; Creswell, 2017) and there is an ample amount of information to form and support the theory.

Research Environment

The difficulties confronting Hispanic students in U.S. schools are well documented. Saw and Chang (2018) also observed significant self-doubt among these students in STEM areas. Both of these findings suggest that Hispanic students more likely than others to disengage from STEM topics. Despite efforts to close it, the Hispanic achievement gap continues to widen. This study uses an educational technology design framework that, according to the literature, has not been used to address this problem specifically. Table 6 lists the design correlations between uLearning criteria and multi-active traits.

Table 6 Multi-active feature-behavior alignment for AREA154

Multi-Active Behavior	Self-efficacy-supporting features of the AREA154 uLearning content-delivery system
Work in a nonlinear fashion and tend to jump from task to task.	Site curriculum is provided through interactive PDFs that can be completed in any order.
Plan actions in accordance with their emotional relevance.	The narrative of the curriculum centers on training the students as agents of a government program that teaches them how to save themselves and their families during a world-altering emergency. It engages motivating feelings of self-preservation and preservation of loved ones.
Act impulsively	In case students are distracted during class time, the content is fully accessible all the time. Because impulsive behaviors lead to lack of studying, the system also allows the student to retake assessments after a poor grade.
Place more emphasis on relationships and family than on school or jobs.	The system provides PDFs that include videos to help students recall the steps for accessing science content they have forgotten or missed during standard instructional time. If calculations or other technical processes are involved, videos are also provided to give students on-the-fly help with problems and complicated concepts.
Highly communicative	The uLearning system has a messaging system that allows students to post questions on pages that pose problems. Ideally, other students will help them solve the problems. There is a secure message system for communicating directly with the teacher. Each day, the site provides students with reminders, guides to which challenges to take and how to pace the work, and alerts about future assessments. Backend site tools allow access to students' usage data (time and duration of access to the site, and what they did there) and academic performance data for each assessment case file.

Table 6 compares the components Multi-Active behaviors with system performance criteria for *AREA154: Apocalypse Division*, which was the investigative instrument used to test the ubiquitous learning concept with real multi-active students. More information on the AREA154 program and its ubiquitous technologies can be found in Appendix A and B. Ubiquitous learning design strategies use special applications of technology to improve multi-active students' experiences with STEM subjects.

The AREA154 curriculum was designed to address the engagement problem and recognize the cultural needs of Multi-Active students. It was tested in-situ over a two-year period as a way to address the traditional pedagogical shortcomings that prompt apathy from the Multi-Active (Hispanic) demographic at San Jacinto High School. Anecdotal observations and site network data were collected to address system usability problems, technical and user-interface problems, and network traffic congestion. The focus on usability helped ensure that students' experiences would be focused on the uLearning environment, not technical issues. This experimental environment meets the ubiquitous learning criteria put forth by Huang (2018); see Table 7.

Table 7 AREA154: Apocalypse Division alignment to uLearning design criteria

Characteristics of a Ubiquitous Learning Environment	AREA154: Apocalypse Division Application
A centrally located hub (a network server in most cases) centralizes the curriculum.	• The server space *area154.net*, hosted by MidPhase Hosting Services. • Experimental sub-domain: *temple.area154.net.*
Lesson content can be accessed at any time.	• Server and site access are open 24 hours a day. • Site access is monitored using the Simple History WordPress plugin.
Content can be accessed through any network-enabled device	• Because the website is free of district-access parameters, it can be accessed through any network-enabled device. • Experiences with the site may vary as its format changes in response to the type of device and type of network connection.
The user's interactions with the system can be stored and analyzed.	• The organizational aspects of the curriculum are handled by the Sensei WordPress plugin. Sensei is an LMS that presents material to the students after they create accounts. • Data such as quiz scores and course completion information can be accessed through this account. • Sensei also provides student assessment data for comparing sections, students, and classes.
The curriculum is real-world applicable, either theoretically or practically.	• The curriculum was designed to present chemistry and associated STEM subjects as tools for increasing one's odds of surviving an event with world-altering consequences. • The year-long curriculum contains five "case files" that teach students how to save themselves and their families.
Instructions and support for learning new material are immediately available on demand.	• The case files are divided into four pieces of training, which can be accessed via an interactive PDF on the temple.area154.net website after students log in. • The interactive training documents are programmed with "Director Briefing" icons that, when clicked, present a clear instructional video on what to do for each section of the training. • The interactive "media icons" are programmed with links to videos that explain complicated content in different ways or provide screen-captured examples of how to complete procedure-based problems. • Interactive icons called "check it out" link the student to new

	net-based media or images stored on the area154.net server. • Multiple supports are accessible in this format at the students' whim.
Responses to formative assessments are immediate and provide opportunities for re-learning and re-assessment.	• Formative assessments, referred to as survival readiness tests (SRTs), are presented in sections of ten questions. • Students are presented with their scores immediately upon pressing the "complete" button. • Students can use online materials to re-train and retake the assessment for a better score.
Systems are usually thematically centered, with a central narrative and evidence of interactive gamification.	• The student plays a member of a black-budget special-access program run by the U.S. government known only by an "AREA" designation. AREA154 operates in specialized high schools and trains teenagers, as the most resilient segment of the population, to survive the end of the world. The government calls this "strategic human asset protection." The kids in the program call it the "Apocalypse Division." • Badges and achievements are provided on the basis of user interaction. • The Agent Leader Board displays the twenty students who have the most achievement points. • Achievements can be completed at any time while a case file is active. • These are thematically related and provide additional STEM opportunities for students.
The system adapts to the cognitive needs of the student.	• Most of the adaptations to the student's experience come from the system designer. • Many of the students present fairly uniform psycho-social behavior. As such, this system was developed to address the cognitive needs of the students using it. • Most of these changes occurred in the first two years of testing, with smaller adjustments based on observations and feedback from users.

Table 7 outlines the AREA154 uLearning system from a mechanical standpoint. It describes how the system was inspired by Huang's (2018) inclusive definition of an effective uLearning platform. The program's inner story-based narrative was derived from two sources: Laborda (2015) and the television program *CSI:NY*. Laborda recognized the power of a narrative to present the notion that any content can be learned more effectively if embedded inside a narrative. This is especially true for game-based learning. *CSI:NY* also provided a significant design influence. The program's curriculum designer served as a science consultant for the show's writing team. on blood suspension chemistry. TV-show consulting is not written research, but the show's design principles are soundly rooted in cognitive dissonance's psychological principles. The lesson this experience provided was clear: Show something that seems impossible and then slowly reveal science as providing clues to solving the case. In the end, curiosity is fulfilled, and the dissonance is relieved.

The STEM program was constructed using ubiquitous learning and technology application guidelines developed by Huang and Springer-Verlag (2016) and built around a centralized theme of surviving catastrophic world-altering events where applied chemistry and other STEM subjects would provide the students and loved ones a means to survive using science. Appendix E contains a mind-map breakdown of the content for entire program.

The NGSS-based chemistry curriculum was broken down into five case files. Each case file focuses on a different end-of-the-world scale event. Students enrolled in the program (or in this case the chemistry class) would take on the role of an "agent-in-training" embedded in a black-budget special-access program run by the U.S. Government. That role would be supported by the use of ID-badges and on-site "Top Agent" leaderboard, which provided a level of gamification to the in-class experience. The thematic applications of survival in a new and dangerous world served as the foundation for delivering the content through a privately owned and cooperatively maintained server. The website, temple.area154.net, centralized all the students learning experiences both in the classroom and outside of it. Screen shot images are presented below, Figures 4 and 5. At the end of each case file, the "agents-in-training" would be subject a summative test called the "Examulation." This part-exam-part-simulation experience puts their training to the test, as they attempt to survive a scripted representation of the event they spent six to eight weeks training to survive. The message, "knowledge is life," becomes a mantra kept close to the students as they traverse the program.

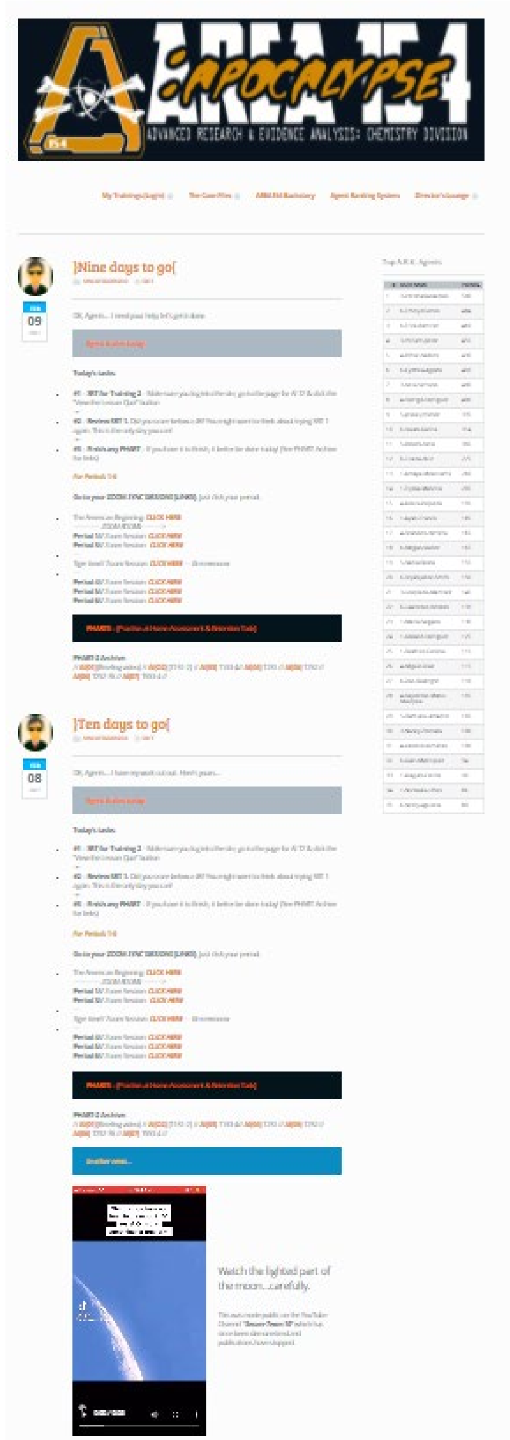


Figure 4 Screen shot of AREA154 Homepage (via PC/Mac/Chromebook)

Note. A zoomed-out screen shot of the AREA154 home page as seen on a PC, Mac, or Chromebook.

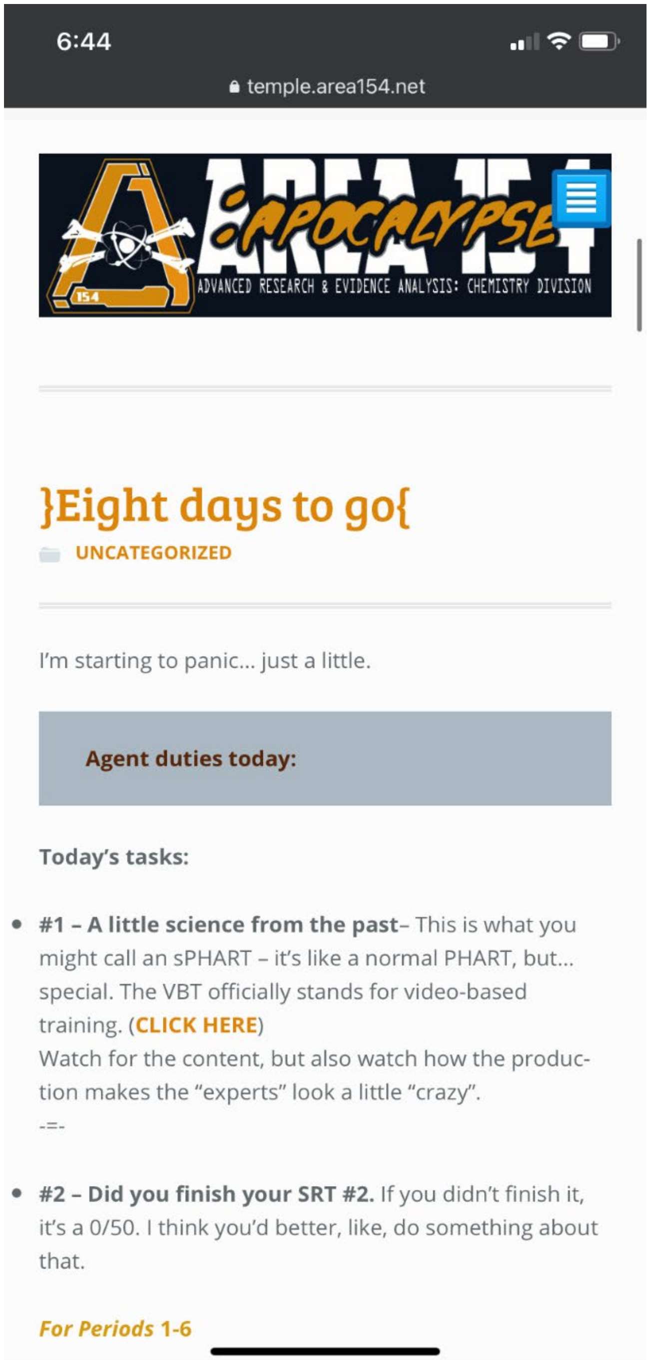


Figure 5 **iPhone 11 Screen shot of AREA154 Home**

Note. A screen shot of the AREA154 home page taken on an iPhone 11.

Participants

Qualifying criteria for participants

The subjects' pool was selected from those who had completed the AREA154: Apocalypse Division program between the years of 2018 and the Spring of 2020. The students' vast majority were juniors, 11th grade, and approximately 17-18 years old. The subjects were selected based upon their level of achievement. As suggested by Lewis's multi-active descriptions, productivity is less of a priority and not a clear measure of how they value learning. As such, the subjects invited to participate in the study were selected based on the following criteria.

Self-identifies as Hispanic:	Can identify at least three of the five multi-active psycho-social norms as behaviors that are prevalent in the student's school and home life.
Completed at least four case files:	Due to covid-19 conditions, many students did not finish the final case file. This is permissible due to their extensive exposure to uLearning technologies. Because the technological design of the content, not the content itself, is the focus, exposure to four of the five case files suffices.
Self-expressive:	The qualitative nature of the study requires students who can recall, ponder, and express their thoughts about their experiences with a uLearning system.
Traditional science classes:	If a selected student was from the 2019–20 school year, they would have to have been enrolled in a

	traditionally taught science class the previous year. Students from the 2018–19 school year would have to have been enrolled in a traditionally taught science class during the 2019-20 school year, meeting the criteria. The students' having a basis of comparison between traditionally taught (linear-active) STEM subjects and uLearning is essential to ascertain the impact the curriculum design has on their perceptions of success.
Various levels of achievement:	Students were selected who had grades of A, B, C, and D and below. Ideally, an equal representation from each.
Comfort with negative views:	To ensure accurate data, one screening criterion includes the ability to freely offer negative feedback or communicate vocally or physically in ways that could be seen as disrespectful to the person asking the questions. Participants must understand that the honest reaction is the most desired one.

Potential participants were reached through the district email system and invited to reply back with questions about the study's nature. They were free to ask any question they wished and could schedule an interview time, knowing that they could choose to back out of the meeting at any time. The subjects were interviewed via a Zoom internet call via the SJUSD Zoom subscription. The school's subscription was used to ensure security for the subject during the interview process. The interviews lasted between 50 min to 90 min. Initially, the study anticipated about 12-14 participants. In the end, 19 was determined by saturation. Data saturation, as defined by grounded theory experts, is the point at which there was adequate data for theory development (Charmaz, 2006). After 19 subjects were interviewed and all achievement levels had been included for analysis, clear trends began to form regarding the theory's formation. According to Chamaz, this indicated the data saturation point had been reached. Moreover, the data began to repeat, no striking or novel situational information was being reported by the students and all of the necessary subsections of students had been sampled. For more information about the participant acquisition process the informed assent consent forms, copies of email invitations, and scripts to potential subjects are available in Appendix C.

The Researcher’s Stance

The researcher has been in science and STEM education for 24 years. Additionally, he has developed several online learning systems for a variety of age groups—namely, sites mesascientific.org and the Atom & Quark interactive DVD series. The researcher spent five years teaching NGSS chemistry at San Jacinto, the school the subjects are all currently enrolled.

The researcher was also the curriculum designer and technical lead for *AREA154: Apocalypse Division.* The developer of *AREA154: Apocalypse Division* was not compensated for that work, nor for the use of the curriculum by the school. The researcher has decades of experience building and developing various learning technology forms and possesses the technical skills necessary to build and deploy the uLearning system. No subject in the study had a direct relationship with the researcher that represented a conflict of interest. All subjects were prior students of the researcher, and as such, quid pro quo arrangements are invalid.

Instrumentation

Interview Questions

The interview questions were written to ask the subject to reflect on their overall experiences and more specific experiences connected to categorical areas of uLearning. The open-ended questions about their experiences were in addition to a list of questions that were very specific with only a small amount of justification. These categorical questions were designed to assess the Multi-Active tendencies exhibited by the student. Ten questions depicting one of two options were provided. One answer was a behavior chosen by someone who was linear-active, the other clearly Multi-Active. The number of responses would provide some inclination about the subjects' behaviors and their blind assessment of their Multi-Active tendencies.

Perceptions and uLearning experiences

Questions about perceptions of success and how those perception-developing experiences were covered in the first quarter of the interview. The questions specifically identified each aspect of Huang’s uLearning criteria. The questions were asked in an open-ended format, which encouraged the subject to detail their experiences. If a simple non-descriptive answer was provided, follow-up questions were posed to attempted to elicit more thick descriptive qualitative data (Creswell & Poth, 2016).

Experiences away from the classroom

Part two focuses on the subjects' experiences with the uLearning program away from school. Questions focused on familial interactions, conversations, family priorities, evidence of STEM CBEs or CREs. Subjects were also asked about their content access experiences, frequency of site access, and other possible methods or locations. The subject accessed or used the site for AREA154 related business. Questions specifically relating to their levels of previous expectancy levels outside the class vs. inside the class were posited further to understand their remote access confidence building or restricting experiences.

uLearning experienced through a narrative

Thematic elements are considered by Huang to be a critical part of the uLearning system. Narratives vary from program to program as well as the intensity of the story narrative. However, this is a non-technical aspect of the uLearning system. For that reason, it had a specific interview section. Questions types in this section included inquiries about experiences connecting narrative and curriculum, which included students thinking about how narrative may or may not have interfered with any impact on their affective filter towards the content. Questions of empowerment, motivation for learning, and the likelihood the subject's family might call on them to lead if one of the case file events were to have actually happened. Finally, the subject was asked about any changes in their global perspectives due to their time enrolled.

Academic perceptions

The final section of questions present questions that asked the subject to reflect on their educational experiences and any possible influences on future STEM classes or careers. The subjects were then asked to compare their lived experiences in prior STEM courses (usually their freshman biology course) in comparison to their uLearning system. Additionally, subjects were asked to articulate their self-expectancy perceptions in STEM-related subjects at the end of the uLearning course. Lastly, subjects were questioned about the influence the teacher had on the course. The instructor was the designer, curriculum specialist, and technical support. It would stand to reason that these students' lived experiences would vary to some degree (or possibly to a large degree) if another teacher attempted to deliver the content. The subject was asked to reflect on that possibility and provide feedback on whether or not it could be effectively accomplished.

Follow-up questions were asked of the subjects if additional information or clarification was required for a deeper understanding of the subjects' motivations (Charmaz, 2006). The interviews were recorded using Zoom's built-in recording feature, which downloads both video and separate audio files. Subjects were all briefed of their rights and responsibilities, and all assent and consent documentation was collected before the interview. Situation-based questions for Multi-Active designation can be found in Appendix G.

Data Collection

Pre-interview

Before attempting the requisition of study participants, IRB approval was sought through Boise State University (See Appendix C for approval and documentation). Extra care was taken with this process as many of the study subjects would be under eighteen. Of the nineteen who were qualified and interviewed, two were over eighteen. As an incentive to compensate the subjects for volunteering their time, they were provided three community service hours to apply to their community service graduation requirement.

Due to forced distanced learning, participant recruiting could only be done through the use of district email. Prior to sending the emails (copies can be seen in Appendix C), permission to use the system was ascertained from the site principal (principal's letter of approval is also in Appendix C). Once students replied and indicated an interest in participating, a mutually agreed-upon day and time was set up. Subjects were asked to present the study's permission paperwork to their parents (or legal guardian) and delivered it back at the time of the interview. Face-to-face contact with the students was not permitted at this time, so consent and assent forms were signed and returned via cell phone image capture. The signed documents were then texted or emailed to the researcher.

The Interview Procedure

On the day of the interview, subjects were emailed the Zoom link inviting them to the secured online call. Once welcomed, the subject was provided a link through the online chat tool, enabling them to open the evening's interview agenda. A sharable agenda served to align all of the most important steps and the order in which they needed to be taken to maintain consistency. In short, the questions presented the subject with a hypothetical situation in which two choice options were provided. One was clearly aligned to reflect Multi-Active behavior; the other reflected a Linear-Active tendency. All of the scenarios presented to students were centered directly on Richard Lewis' work on cultural behaviors (2010). Figure 6 displays a screen capture of the interview agenda shared with the subjects.

Research

Briefing statement

First, thank you for taking the time to do this. I know you have things to do, and working my project into your schedule is much appreciated. Before we start the video that is designed to walk you down memory lane of your AREA154 experiences, I wanted to brief you a little on the project and your role in it.

- **Step one:** A little about what I'm going – briefing + That whole consent thing (The permission documents).
–
- **Step two:** A little question and answer session where we talk about some of your social behaviors
–
- **Step three:** Watch the video here. Now that you've read the questions let's take that walk down memory lane.
–
- **Step four:** The interview – I will be asking you questions that focus on your experiences with the AREA154 system, your interactions with it, and how those interactions affected you and your feelings of confidence in STEM-related subjects.
–
- **Step five:** I might schedule a follow-up call or Zoom call to ask follow up questions.

That's it!

Your responsibility as a participant *is to provide honest, trustworthy, and well thought out responses. There are NO WRONG ANSWERS. If there is reason to be critical, be critical. Critical evaluation can have positive effects as well as effects that would be considered not so great. All data is valuable, and if there are problems with the system, your feedback will help make for a better, more robust experience in the future.*

If you've read the interview questions, then you're ready to proceed.
[Review video begins]

PERMISSION

STEP 1

You've been CHOSEN to participate in a study that focuses on the technology design used for the AREA154: Apocalypse Div. Chemistry class. Here's how this works:

- If you are over 18: **Click here**
- If you are under 18: **Click here**

You might want to open and save a copy to your device.

Figure 6 Screen capture of interview agenda shared with subjects

Before the official beginning of data collection, the subject was briefed on the steps of the interview (top Figure 6). Perhaps the most critical section focused on the role of the subject, labeled in bold above as “Your responsibility as a participant.” The section states the importance of the subject’s honesty and promoted critical evaluations of their experience. In capital letters, it was noted that there are no wrong answers as long as what is share authentic and a genuine reflection of their lived experiences. The data collection would only move forward after the subject was aware of the criteria and acknowledged them on the session recording. Additionally, as part of Step one was a convenient place to download consent and assent documentation in the event the subject lost their prior copy or forgot to have the documents signed.

The second step on the interview agenda presented the subjects with situational questions that would later be tabulated and axially coded to assess their multi-active tendencies. The exact list of questions can be found in Appendix G. The ten questions were read to the subject in a conversational manner. Subjects were encouraged to ask questions about the situation to ensure they clearly understood the context of the options. Moreover, they were encouraged not to overthink the situation and act as instinctually as possible.

Once completed, the subjects were invited to watch a fifteen-minute-long movie compiled from instructional media. The video contained case file briefings, website screen captures, and images of the classroom with other artifacts that reminded them of their experiences in the program. Subjects accessed the video by clicking the play link on the agenda page. Generally, the subject chose to turn off the video feed from the zoom call when watching the video. Subjects were left to watch it uninterrupted and instructed to send a chat message indicating they were done at the end of the video.

The primary interview session begins after a quick discussion about what memories were brought up while watching the video. Follow-up questions were asked to help broaden the reflective period and enhance the subjects' memory of past experiences. The interview questions were asked by category. The list and order of questions are located in Appendix F (the web page as seen by the subject) and Appendix D.

Interview memos. After each interview was completed memos of the student's interview, the researcher reflected on the subject's answers. If needed, a review of the interview after it saved to secure storage. This process was done several times in this study to clarified interview anomalies. Student tone, language, body language (if applicable) was reflected on and then added to the subjects' data profile (All student profiles are available in Appendix I).

Additionally, time was taken to reflect on the student's observational behaviors in class during his or her program enrollment. Characteristics reflecting class involvement, work habits, frequency, and type of interactions helped translate data and understand the subject's experiential ontology. More detail about how these memos helped build subject analysis profiles is provided in the analysis section.

As mentioned earlier, all but one of these interviews were conducted through Zoom calls. The subjects' manner of responding to each question, the words they used, and the body language (when usable) were all considered data during the interview process. Not all participants elected to keep the camera on view. The one interview not conducted on Zoom was conducted through email question and answer exchanges. The dialog between the researcher and the subject were added to the interview transcripts and coded with the same coding methods.

Data collection and storage

The recorded video and audio data were recorded by Zoom and stored on a password-protected computer within an encrypted folder. Additionally, any emails and communications that the researcher had were both stored on the password-protected account of the researcher as well as printed out as PDFs and stored in the encrypted folder with the media recordings. Audio transcriptions took place online. As such, a copy of the interview data was located on the transcription service. Those copies have been downloaded into MS Word files and stored in the encrypted data storage folder. Copies still exist online and are secured through encrypted account user access.

Data Analysis

Interview transcription

The vast majority of the transcript was produced via an online algorithm. The transcription was not perfect and required proofing to clarify words, phrases, or jargon. For example, in instances where the researcher and the subject spoke over each other, manual effort was utilized to break up the text and re-transcribe it. Specialty words like "SRT" and "ATN" and "Examulation" were often mis-transcribed. In instances where the subjects' recorded volume was low, the error rate was higher, and manual transcription was needed. Each of the digital recordings was transcribed and corrected on the transcription site. Once completed, the file was exported to an MS Word document for uploading into NVivo for coding and formation of larger groups within the data pool.

Coding procedures

Procedures for coding in Grounded Theory

During the coding process, the researcher's epistemological approach's influence reveals the reasons for the multiple types of GT (Charmaz, 2006; Greckhamer & Koro-ljunberg, 2005). According to Glaser and Strauss (1967), proper coding includes constant comparison among acquired data at three levels. These levels vary upon the type of investigation being undertaken. The three layers used in this study were open, focused, and selective (in the form of magnitude coding). Grounded theory does not have a prescribed procedure for the coding process. In Table 5, the coding process is referred to as "Coding and continuous comparison of the data enable patterns to emerge." This rather generic description suggests that the type of coding and the order of the coding process must reflect the needs of the investigation (Wu & Beaunae, 2012; Charmaz, 2006; Greckhamer & Koroljunberg, 2005; Glaser & Strauss, 1967; Strauss & Corbin, 1990; Charmaz & Belgrave, 2012; Thornberg & Chamaz, 2014; Grbich, 2007). According to Glaser and Strauss, two coding phases are used to develop concepts that explain the phenomena: A simple phase (breaking data down into small segments and grouping them to capture patterns in the data) and substantive (selective or focused choosing of a core category and relating other categories to it to explore emergent patterns). In this study, the pool of data was initially organized into four large groups that represented "Phases of the students' experiences." These large groups were coded into categories. The majority of the categories reflected the structured questions asked during the interview. The study was specifically interested in the uLearning system's role and the type of experiences it provided. Logically, the categories would emerge from the content in the questions.

Finally, the relationships between the categories were established using magnitude coding—this type of coding allowed for using descriptive rubric-based values. The value rubric, in this case the Affective Theme Value, related each of the categories' confidence building experiences and their impact on the participants. GT-type investigations typically include large amounts and various types of information (Wu & Beaunae, 2012). For this reason, the coding starts with simple coding and organizing the information into large groups of related data before applying specific coding practices. GT offers this flexibility to make sense of the participants' unstructured experiences in a structured way.

Multiple coding passes to process large amounts of data

The first open coding phase would explore all of the interview data, the server backend user stats, site-based (WordPress Plugin) user login dates and duration, and the Aeries student achievement data. The open coding led to identifying several possibilities for initially organizing the data pool. The data was organized into specific groups that were organized around the subjects' "Phases of experience." Each of these phases represented a different aspect of the subjects' year-long AREA154 enrollment. Phase I described the experiences the student had with the site and the site's interface. Phase II focused on experiences directly related to the uLearning elements. Phase III represented the collection of experiences that were outside of uLearning influences. Phase IV described the subjects' collective feelings about their confidence building experiences as a verified Multi-Active person. The initial data pool processing used open coding to attempt to identify groups in which the data could be organized for further coding and organization. Figure 7 below illustrates the formation of the initial four phases (organizational groups).

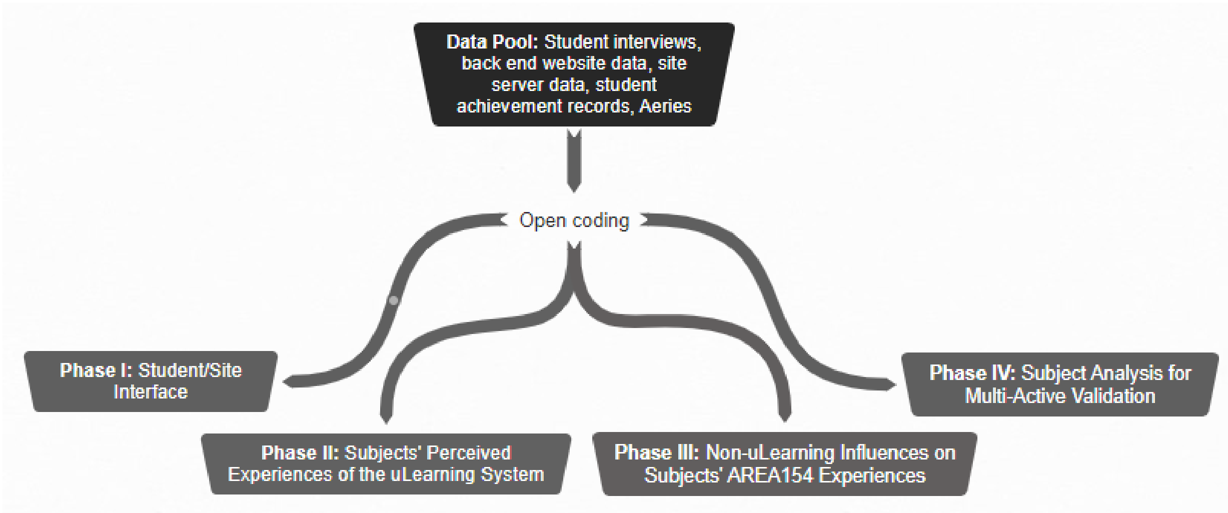


Figure 7 Data analysis flow.

Each of these phases was then coded, which focused on specific categories that impacted the subjects' learning experiences. For example, the focused coding for the data in Phase I revealed three different categories that significantly influenced the subjects. In Phase II, more categories were discovered that mirrored the uLearning system criteria and the data reflected the subjects' experiences with it. Phases III and IV were coded for important and influential categories in a similar manner.

The last layer of coding provided a unique opportunity to assign numeric values to qualitative data called magnitude coding (Miles, Huberman, & Saldana, 2020). The vast majority of the initial open coding was completed in NVivo, an industry standard for QDAS analysis tools.

Magnitude coding and implied intensity

Magnitude coding is a qualitative technique that, according to Miles et al. (2020), facilitates a sense of intensity, frequency, direction, or some equivalent sense of commodity. Magnitude coding could be seen as unorthodox. However, Glaser (1978) stated, "It is necessary for the grounded theorist to know many theoretical codes in order to be sensitive to rendering the subtleties of the relationships in his data" (p.72) explicitly. Additionally, magnitude coding was used to facilitate middle school STEM robotics students' measures in a qualitative study by Snelson et al. (in press). The values were coded by the researchers, who were both science STEM teachers with decades of instructional experience. Magnitude codes of 1, 2, or 3 were used to indicate different intensities or magnitudes to which the student displayed characteristics of computational thinking. In the end, values were averaged to reveal the overall frequency and intensity of computational thinking among the subjects in the study.

Analysis procedure for cross-verification

The students' claims are just that, claims. Unless they can be supported by a secondary source of information validity of their claims remain in question. As seen in Figure 7, the student interviews are combined with other sources of data. Phase IV uses frequency coding to help build the behavioral profile of the subjects. The correlation of frequency codes and academic history provides a type of cross-verification for the subjects' Multi-Active tendencies and achievement data to solidify subject testimony.

The Affect Theme Value – a unique type of theme

The Affect Theme Value idea was derived from English language acquisition researcher and distinguished professor Stephen Krashen. His ideas about second language acquisition identified five hypotheses of learning. One of those was called the Affective Filter Hypothesis (Krashen, 1981). Conceptually, Krashen imagined a filter that would block out learning content if there was a reason or some bias that afforded the student to do so. Influencing factors included learning motivations, physical well-being, the relationship with the teacher, past experiences with the learning material, seemingly the same type of factors that impede Multi-Active students from truly engaging STEM subjects. Saw and Chang (2018) noted Hispanic students in the study held a general bias that impeded the ability do math (or science). That bias against a subject, for whatever reason, was the filter that Krashen spoke about in his research. As such, the Affective Filter Hypothesis represents the psychological framework for the Affect Theme Value magnitude coding. *The ATV is the theme*. That idea, while possibly unconventional, supplies an analytical power for interrelating a large number of factors surrounding the complexity of the subjects' learning perceptions.

The categories' development comes from the focused coding of the data found in each Phase (I-IV). Once these have been identified, all of the subjects' interview data pertaining to that category was organized into one of five affective themes (an ATV). Subject interview data that indicated negative and highly restrictive experiences would be categorized as a '1' in-line with the criteria on Table 8. Interview responses that indicated a certain identified category was neutral or had no real positive or negative impact were assigned a '3', and highly confidence building experiences were assigned a '5' according to Table 7 guidelines. The researcher was responsible for assigning the subject's responses an Affect Theme Value (magnitude code). The following questions were part of the ATV magnitude coding process:

- What were the subjects' responses positive in tone or negative?
- What words were used to describe the response?
- What was the tone of the response from the recorded interview?
- Knowing the student, what is the likely intent of the statement?

The researcher, who was also the designer of the AREA154 system, and the instructor for the subjects, also assigned Affective Numbers to the subjects' statements. The researcher's year-long exposure to the subjects provides valuable insight into subjects' lived experiences and the intended meaning of interview responses. Table 7 indicates the specific rubric by which the student interview data (as well as other data) were assigned Affect Theme Values.

Table 8 Affect Theme Value evaluation rubric

Affect Theme Value	Evaluation criteria
1	Subject used strong critical language, with vocal cadence and volume intensity that correspond to frustration and strong disapproval, in combination with other behaviors that indicate that the topic of discussion was a **strong area of success or expectancy restricting.**
2	Subject used moderately critical language and vocal cadence and volume intensity corresponding to mild disapproval or behavioral signals that similarly suggest the topic was a source of **mild success or expectancy restricting.**
3	Subject gave no vocal or textual indication that the topic of discussion was promoted success or was an area of success or expectancy reduction. The subject indicated a **neutral response.**
4	Subject gave vocal or textual indication and used vocal cadence and volume that corresponded to positive, success- or expectancy-building experiences. The subject's overall demeanor suggested the topic of discussion was a source of **moderate success or confidence building**.
5	Subject used strong supportive language and vocal cadence, and volume intensity that corresponded to pride and self-efficacy. In combination with other observable behaviors, this indicated that the subject experienced **strong areas of success or confidence building**.

As mentioned earlier, inferring magnitude data involves having a keen understanding of the subjects' true meaning behind their replies. For example, suppose in the data analysis, the category of site organization was to be analyzed, and the subjects gave a variety of responses on this category. The text might indicate that some responses were similar in meaning: Subject 1 might say, "Oh yeah, it was just great," and subject 2, "It was a great help." Without the audio recordings, one might score these responses similarly. However, subject 1 used tones of sarcasm and resentment about the organization, and their response should receive an ATV of 2. By contrast, subject 2's tone indicated genuine support and thankfulness, so subject 2 should receive an ATV of 4. For the overall impact of the organization category, the ATV score was averaged to 3. Failure to consider the tonality of the conversation and other non-verbal cues in situations like this could skew the data in unanticipated ways.

Category Affect Theme Values

The Affect Theme Value was used to formulate magnitude-based themes that would reflect confidence building experiences (CBEs), or those that were confidence restrictive (CREs). Values over three would constitute various intensities of CBEs, and Affect Theme Value under three would represent a negative experience that could promote Krashen's learning inhibition effect. Every category revealed in each phase was evaluated for an Affect Theme Value (CBE). The average collective ATV for each category is the category's affective influence within the AREA154 uLearning program as reported by the nineteen participants.

Phase Affect Theme Values

Similar to how an ATV was developed for each category, the categorical ATVs can be collected and averaged to provide each phase with an overall Affect Theme Value, a numerically valued theme displaying the subjects' overall experience determined by magnitude coding. Moreover, the average of all the phase's ATVs provided a collective Affect Theme Value reflecting the confidence building experiences (CBEs) for the entire

AREA154 program as a uLearning experience.

Overall, the inclusion of the magnitude coding provides certain evaluative flexibility. The possibility of learning how changing any one part (theme) of the system could affect the overall system impact is now possible. Overall the data pool is initially filtered into phases of experience from the subjects' perspective. Each phase was then selectively coded for categories that were then magnitude coded to reveal the impact each category had on the participants.

Ethical Considerations and Trustworthiness

The participants who volunteered were a top priority for the study. The procedures formulated for the collection of data allowed the subjects to maintain a comfortable and stress-free interview environment. Subjects were encouraged to keep their cameras on, though no efforts were made to push them out of that comfort zone if they chose not to do so. Additionally, subjects were offered a form of non-monetary compensation in the form of community service hours which help them meet the graduation requirement of 10 such hours of service. The compensation was a form of reparation. However, community service hours are not considered among students to be a highly valued asset. Many of the subjects who participated had already completed their requisite ten hours. In summary, the restitution offered was not valuable enough to entice subjects to be anything but completely authentic with their replies.

The parents of all study subjects were contacted via email and notified about the study. Additional details about the study were provided to parents upon request. Prior to the informational interview, the consent and assent forms were collected via the signed document's cell phone photograph. Those images were then forwarded to the researcher, where they were securely stored.

Subject data will be kept confidentially and stored securely for the requisite five years as stipulated by the Boise State University Internal Review Board.

Chamberlain-Salaun et al. (2013) discussed the ethical considerations that must be made when using grounded theory for qualitative investigation. There is a danger to undertaking grounded theory research in cases where it is essential to produce evocative, descriptive, thematic accounts of the social sphere of influence. The drive to formulate a theory could supersede the collection of rich data. The researcher thus must be familiar with the people who are providing the primary data. Social familiarity might appear to be a problem for bias-free ethical research.

The *AREA154: Apocalypse Division* curriculum was researched, designed, and implemented by the primary investigator of this study, who was also the instructor for the students who participated in the study. The topic of familiarity was dealt with by employing guidelines from Creswell (2007), and the Australian Code for Responsible Conduct of Research (2007) was used to develop research protocols and a framework of acceptable academic standards that included the following:

- **Promote responsible research.** Maintain open communication between researchers, participants, and parents or guardians throughout the data collection. Provide an expectation of high ethical standards and responsibility.
- **Provide competent management of acquired data.** All research will follow lawful practice and be conducted in a risk-free environment. Risk management and the safety of participants are the highest priority. The primary research data

should be clear, consistent, and organized to minimize errors and be useful to future researchers who need access to primary information sources.

- **Report research responsibilities.** Findings of this research will be reported responsibly and disseminated properly. Findings by other researchers or sources outside the study will be noted and properly cited.
- **Disclose conflicts of interest.** Although there is no stated requirement to disclose the details of any conflict of interest, such a confidential agreement between parties for personal reasons, it is advisable that potential conflicts be disclosed.

<u>Potential conflicts of interest.</u> In several interviews with site administrators, the topic of selling the curriculum was discussed. The program had not been appropriately vetted to ensure adherence to ubiquitous learning technology design factors. However, during the year in which the primary research was to be conducted, two schools asked to use the system to include more STEM materials in their own offerings. Hope Academy of Bishkek, Kyrgyzstan, and the Flabob Airport Preparatory Academy in Riverside, California, requested to use the program under duress of extraordinary circumstances. Permission to use the curriculum was granted to Hope Academy based on opportunities for future research in that area of the world. No money was exchanged for the use of the curriculum. Flabob Airport Prep was also offered permission to use the curriculum free of charge. Still, the academy insisted on donating $600 to help offset the $1,400 annual cost of the server that manages the high traffic volume.

Given the potential market value of *AREA154: Apocalypse Division,* questions of data and conclusion reliability are important. . If there is to be any long term value to expanding the program, the consideration enhancing the findings of this study would ultimately prove fruitless when the product applied, tested, and repeating data sets demonstrate the original findings to be baseless. Ironically, after decades of designing, building, researching, redesigning, and re-implementing, a researcher and engineer would argue that these potentially result-altering biases are meaningless and ultimately counterproductive. Credibility, once lost, can never be fully recovered. Therefore, honesty and transparency in data collection and analysis is a top priority.

The following statement by this study's primary investigator may counter worries of bias or misrepresentation of findings:

> The *AREA 154: Apocalypse Division* program is the latest result of a long line of educational technology builds that go back decades. When I first started building EdTech-based learning systems, I enjoyed the positive feedback. Because my products were a sort of labor of love, I resented and avoided the criticisms. What I quickly realized was that positive feedback has its place; it was largely useless. It told me that what I was doing was working for one type of person. The feedback that was the most meaningful was that which identified problems, issues, points of confusion, and user interface problems. As I matured in this process, I began to actively ask the students (participant users) to find any issues and problems they had and bring them to me. I would often reward their finds with some form of operant gratification, like a Jolly Rancher. After developing a thicker skin, so to speak, I realized that my systems were improving much faster and provided a much

> better working program for the students of the following year. Perfecting the interface was one of the reasons why this investigation was held off for several years so that the user experience and materials could be properly constructed. My primary motivation is to make powerful learning experiences for those who need them. That cannot be done unless the data acquired from the participants is open, honest, and collaborative in discovery. (Torrence G. Temple)

In short, the principal investigator, who was also the designer of the uLearning system and was the course instructor for the participants, claims that the potential for skewed results is minimal. The most essential data are those that provide insights for progress, and inaccurate data always impede progress. This system is not in its final form, and the data acquired in this study will provide insights for improving it.

Summary

The goal of the investigation is to develop a theory about how multi-active students interact with uLearning environments. Grounded Theory (GT) guides the methodology, as it is ideally suited to investigating relationships, developing meanings, identifying motivations, and capturing a wide range of facts about the environment and experiences of that reality (Prigol & Behrens, 2019). Grounded Theory represents a lens with a unique set of criteria that allows the researcher to be tightly connected to the subjects and the study's environment. Charmaz (2006) described the role of the researcher as a theoretical constructivist, which was reflected through the interview and data collection protocols. The theory seeks to develop how the subjects’ sense of expectancy and success was developed in psycho-socially conflicting environments. Procedural emphasis was on the construction of meaning between individuals and the research environment. The study's prescribed stages for data collection and analysis described the process as an iterative exchange between the data, the organization of the data, and the cross-checking of the resulting concepts with continued observations. Ultimately, this formed a multi-staged interconnected theory that can be measured through the use of magnitude coding.

The study participants, the subjects, demonstrated a dedication towards providing their honest, forthright interpretations of their experiences within the uLearning system called *AREA154: Apocalypse division*. Great care was taken to ensure their confidentiality, safety, comfort, and the parents' peace of mind who supported the subjects' decision to participate.

The analysis of the data will be presented in the following chapter. Through the use of various coding methods, four experiential "phases" were found that encapsulated all the categories connected to subjects' experiences. The data pool was extensive, and to promote procedural transparency, results were presented in stages along with developing theory. As each phase analysis is completed, the theory will be updated throughout the chapter, leading up to the complete grounded theory's current iteration at the end.

FINDINGS

As mentioned in the study's introduction, the AREA154 uLearning STEM content delivery system was entered development two years before the study began. NGSS chemistry students at San Jacinto High School would experience the program at school, interact with it, take it home, live with it, and learn with it. Learning about the students' successes and failures, comments, and complaints and anecdotal feedback about their lives' challenges functioned as a sort of preemptive data gathering. The program remains active now as a testament to the feedback of those past students. After two years (2017–2019) of feature-building and testing, the time came to formally ask the questions that kept cropping up over the development period. Over that time, the failure rate in that course (chemistry) was reduced significantly among the students in the program, while chemistry failure rates in the department remained relatively unchanged. The question in this study posits the possibility that this success could be due to an increase in confidence building experiences and that may well lead to an increase in personal expectancy and explain the increase in achievement. facilitated by the students' exposure to a uLearning designed content delivery program.

Initial open coding suggested breaking the data into several phases of analysis based on experiences the participants talked about that either were confidence (expectancy) building or confidence (expectancy) restricting. The groups that evolved provided four distinct phases of their AREA154 experience that influenced the participants. When focus coding was applied for Phase one, three categories emerged, illustrated in Figure 8.

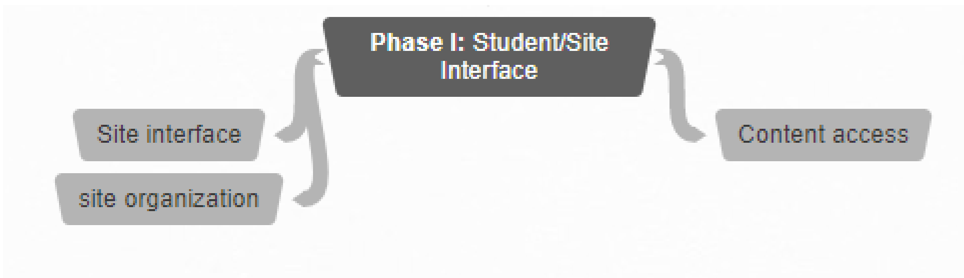


Figure 8 Results from focus coding Phase one

Phase I : Categorization on Student/Site Interface

Coding in phase I resulted in three distinct categories, site usability, site organization, and content accessibility. Table 9 represents subject interview data that reflect their experiences using the site. A quote from one of the students was used to demonstrate the "feel" for the responses given at each ATV level. For example, at an ATV level of 1 – there is a quote that describes the sort of reactions that students had that reflected that level of confidence building restriction. Below the subject interview data are the magnitude coding results, indicating a positive or negative experience, which is then magnitude coded to provide an Affect Theme Value. These values convey a collective sense of the subjects' confidence restricting experiences (CREs) or confidence building experiences (CBEs). (The Affect Theme Value [ATV] has been described in more detail in Chapter 3.) These numeric values aid in building a semi-quantitative method of tracking and defining the qualitative data—Table 8 displays subject interview data reflecting the theme of site organization.

Table 9 Magnitude coding for category - site organization

ATV Code	Number of participants coded at this value	Sample participant response for each ATV	Total for ATVs (Affect Value x Number reported)
1	1	"It [the site] was kind hard I never really figured out how to use it."	1
2	3	"The site was a little hard to figure out. I was sort of lost."	6
3	3	"Finding and using the site was no issue to me."	9
4	5	"It (the site) was certainly not designed like anything I have ever had to use. It took some time to figure out. Not too long after that, it was amazingly easy to use and predictable. I always knew where everything was."	20
5	4	"I have never seen anything so complete and so well organized in a science class. any class."	20
	Total responses 16/19*	Total Magnitude for the category: **ATV value site-organization** (Total Mag/16):	56 **3.5**

*Not all 19 students provided data on this topic

ATV: Organization

The theme "organization" revealed that some students experienced problems with the site and its organizational style. Some characterized it as confusing, saying it took some time to learn. Others stated that the interface was unlike anything they had worked with before, so it appeared strange. The majority of the students who contributed to this theme voiced responses that seemed to express success and confidence in using the site. Averaging all of the evaluated subjects' responses produced an Affect Theme Value of 3.5. This result suggests that the site's organization has a slightly positive effect on building success and confidence with the site's subjects.

ATV: Usability

The second prevalent category that arose around the site structure and deployment was usability. The category of usability included codes that referred to how well the students could conduct daily activities on the site. These activities included using the home page navigation, getting important information from the daily posts, reaching SRTs, and performing during the Examulations.

A small portion of the data surrounding the site's usability involved statements about forgetfulness and a general sense of unfamiliarity or just forgetting the rules for using it. Most of the subjects' responses appeared to support the site's responsiveness, reliability, and stability on every platform. Of course, this depended on whether the network they were on was functioning well enough to match the performance of the AREA154 site server. The ATV data reveal an Affect Theme Value of 3.8. The ATV value seems to indicate that the usability of the site enhances subject CBEs. Table 10 displays the data surrounding the usability category.

Table 10 Magnitude coding for category - site usability

ATV Code	Number of participants coded at this value	Sample participant response for each ATV	Total for ATVs (Affect Value x Number reported)
1	1	"I don't remember where those were located or really taking them [SRTs]."	1
2	2	"Everything was good, I sort of fell off in the end. That was my part. It was just me."	4
3	1	"I would need things and then they would be pointed out in class, and I was like, where was this when I needed it?"	3
4	8	"I had no problems getting what I needed or doing the class stuff. Sometimes I would have network issues, but that's not the site really."	32
5	4	"I could access and use the site on my Chromebook, phone, tablet. I would even take my classwork to picnics and do it there."	20
	Total responses 16/19*	Total Magnitude for the category:	60
		ATV value site-organization (Total Mag/16):	**3.8**

*Not all 19 students provided data on this topic

ATV: Content accessibility

The third category that arose around the subjects' site experience was content accessibility. This area addressed the functionality of the links, responsiveness of the LMS functions (keeping track of assessment scores), site up-time, login speeds, download speeds, and the site's performance at school (on the SJHS network) and on home networks. Subjects rarely commented on these topics unless there was a problem that inhibited their access or their site-based needs were not being met in a "reasonable" amount of time. The data reflects subjects comments regarding their experiences getting to what they needed. A few respondents mentioned the quick access to assessments, while most talked about their frustration with internet connections. Table 11 presents information about the category of content accessibility. Sometimes accessibility means getting access to assessment results, and if buttons do not work, learning stops. Accessibility can play a role in the amount of effort a subject may utilize before giving up and moving away from the learning content.

More of the subjects appeared to have issues with the content accessibility, specifically in terms of losing passwords, losing their SRT scores because the site did not record them, and other site experiences. The observational data collected by the instructor indicated that most of the time, the error in SRT score recording stemmed from a student's misunderstanding of what constitutes "submitting the test." There are two potentially confusing buttons on the SRT page. One reads, "Complete," and the other reads, "Save." Students would often click "Save," thinking that they had turned in the test. However, clicking "Save" paused the quiz and put the student in a state of "In progress." The SRT has a score of zero until it is marked "Complete" and graded. Data related to this category also demonstrated the effect of a good network connection on student learning. Comments from subjects reflected frustration with download times, connectivity, buffering, and other connection and network-related issues. Notably, though, these comments changed when students discussed their experiences while logged into the SJHS student network. While a notable influence, network experiences were not assigned an ATV value due to a lack of specific data. Thus, they were color-coded and added to the diagram to represent their influence.

Content accessibility was also reflected in the subjects' user patterns on the AREA154 site. Consistent patterns of little to no activity over weekends and school breaks were common over several monthly bandwidth reports (Traffic data can be found on Table L-1). Additionally, the separation of school and home activities grew starker as the semester progressed. By the Thanksgiving break, weekends and vacation days were utterly devoid of site traffic. Subject interview data suggested four possible explanations for the drops in activity.

1. Students **could not** get to the class site because their mom or family interfered with plans to do work.
2. Students **would not** do the work due to a lack of motivation or discipline.
3. Students **did not need to** do the work because they had finished it in class.
4. Students **were prevented from** accessing the site due to unreliable internet connections.

The comments about the subjects' experiences with accessibility appeared to support some of the notions about networks made in the section about content accessibility. Other comments, however, appear to be beyond the scope of the uLearning paradigm.

The category for content accessibility, based on the magnitude coding, provided an Affect Theme Value of 2.8. This score indicates that network access played a critical role in the subjects' ability to access the class content as well as the amount of time that subjects' cultural priorities supersede the ability to access learning. When after-hours access is attempted, back-end data demonstrated a trend for late-evening to late-night usage patterns. The overall score suggests that the category of content accessibility, especially if accessed outside of school. The subjects' interview data focused heavily connection issues at home. It was suspected that the slightly restricting effect on the subjects' sense of expectancy was associated internet connections made outside the school. This score might also shed light on the behavioral tendency to finish their STEM work. Table 11 displays results for site content accessibility.

Table 11 Magnitude coding for category - content accessibility

ATV Code	Number of participants coded at this value	Sample participant response for each ATV	Total for ATVs (Affect Value x Number reported)
1	1	"We had problems with our home internet. There were days where I would try, and just give up."	1
2	8	"I only had problems at home, lots of buffering."	16
3	3	"NO, it [loosing network access] wouldn't happen like a handful of times, maybe not too often."	9
4	3	"Some teachers took days to grade my work. I liked how quick the site graded the quizzes."	12
5	2	"The STRs would get graded really fast. I loved that part. I felt like I had a chance to relearn what I missed and redo it [the SRT]. I really loved that part."	10
	Total responses 17/19*	Total Magnitude for the category: **ATV value site-organization** (Total Mag/17):	48 **2.8**

*Not all 19 students provided data on this topic

Note: Comments reflecting negative experiences appeared heavily focused on the subject's ability to get network access away from school. Comments reflecting school access appeared to help in the view of several subjects, who said they came to school specifically to use a reliable network. This result is consistent with informal data collected during the AREA154 development period. Students would often complain about their home connectivity. The phrase, "Bro, my internet sucks" was fairly commonplace.

Visualization of relationships between influential factors

In Figure 9, the categories and themes have been presented in a colorized flow chart. The colors are meant to illustrate the different types of coding used to form the next layer of the analysis. For example, from the raw data pool four groups were identified that were noted as "phases" by open coding the raw data. Following focused coding, specific categories were formed that, generally, reflect the questions that were asked. Magnitude coding follows which then produced the results seen in Figure 9. The results for each group or phase developed from the data pool were processed in the same manner.

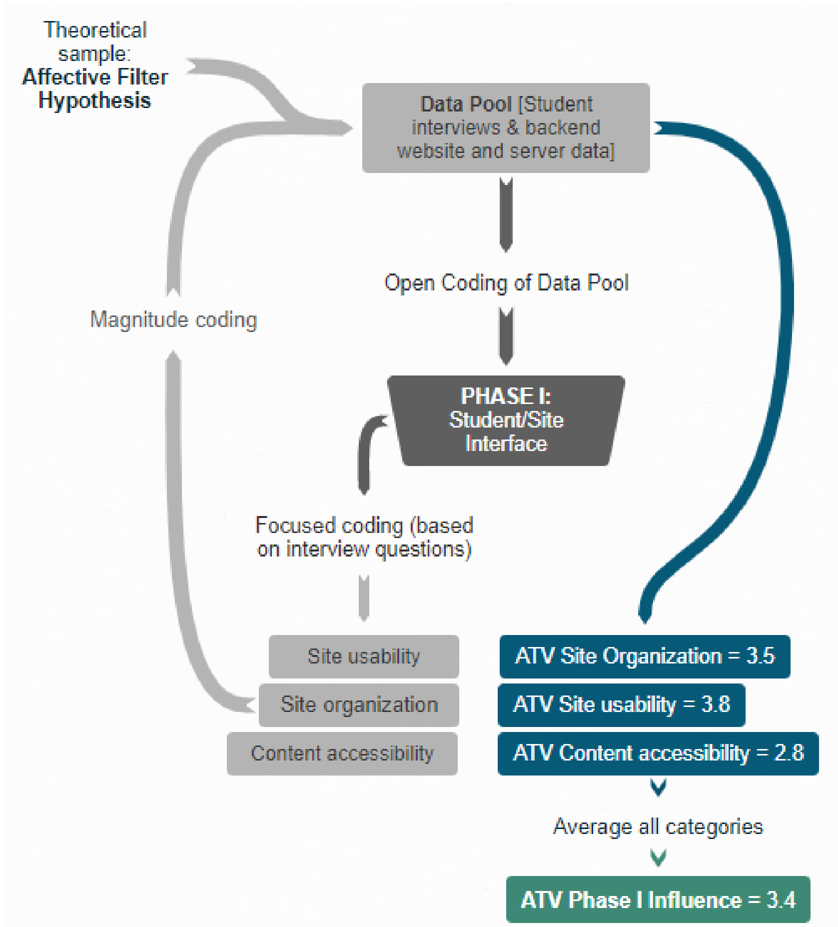


Figure 9 The visualization of Phase I Affective Theme Values

Note: The diagram illustrates the data analysis process from the open coding of the data into major organizational phases, from that phase to the focused coding into categories that reflect the questions asked to the students. Once formed the categories were magnitude coded based on the various responses provided by the participants reflecting their various responses to that category. A numeric theme value was provided to each category once all of the participants responses were summed and averaged. An overall phase ATV is the result of the summation and averaging of the individual category ATVs.

Phase II: Categorization on Experience of uLearning System

The second-phase represents the subjects' experiences and responses for each of the uLearning criteria described by Huang and Springer-Verlag (2016). The results of the coding appear in the same format as they did in the prior section. Figure 10 illustrates the categories that emerged from the focused coding.

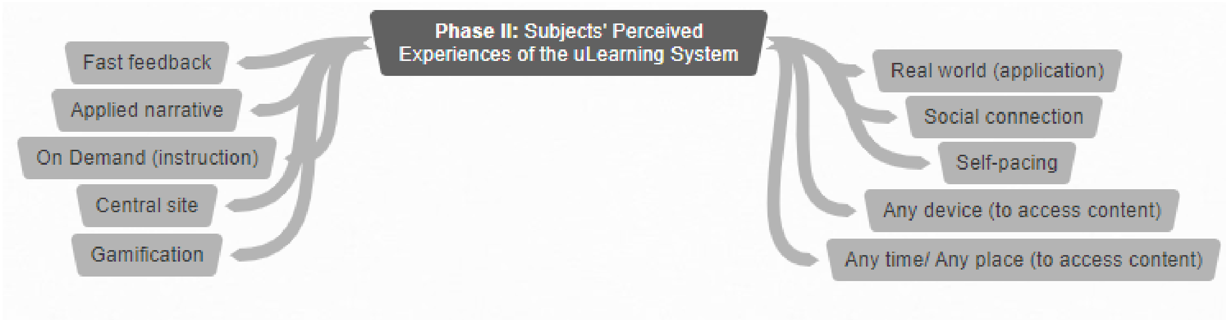


Figure 10 Categories that emerged from focus coding of Phase two

Each of the uLearning criteria had subject-specific feedback that reflected each of the five layers of impact (The ATV magnitude coding). Each example displays a value reflecting how many times a similar comment was made at that same affect level. This phase's goal was to develop a numerically derived Affect Theme Value for each of the uLearning criteria, which assessed each criterion's individual impact. All of the particular criteria were then totaled to provide summative value for the collective impact of the uLearning design on the overall AREA154 experience. The data analysis results begin with a description of the categories developed around the uLearning criteria, their association with Huang and Springer-Verlag's (2016) uLearning standards, and whether the AREA154 system meets each uLearning criterion. Table 12 lists the generated themes.

Table 12 Categories for uLearning criteria and AREA154 features

Categories	uLearning Definition (Huang)	AREA154 Examples
Self-paced	Content that can be completed on a schedule that fits the needs of the individual learner.	Flexible deadlines with SRTs and ATN checks (formative assessment). Site access 24/7.
Anytime/anywhere	Anytime/anywhere access to the curriculum.	temple.area154.net, accessible by any internet-connected network.
Fast feedback	Immediate feedback on formative assessments.	SRTs (Survival-readiness tests—formative assessments) provide instant feedback to learners and opportunities to learn from mistakes.
On-demand instruction	Need-driven availability of curriculum resources—support instruction is available in predictable places and on-demand to help explain content away from the classroom.	PDFs can be downloaded from the site and contain built-in instructional guides for students who need procedural and content-related assistance 24/7.
Real-world	Content is directly applicable to the real world or a theoretical real-world condition.	The uLearning system is based on scientifically sound but improbable real-life world-altering scenarios. Surviving these events depends on being able to apply STEM skills to real-world conditions in order to survive.
Narrative	Thematically driven and applied narrative.	*AREA154: Apocalypse Division* contains five self-contained world-altering events. Each begins with the start of the event, the impact, the event's power, environmental effects, and new threats that evolve due to the event.
Gamification	System has a competitive or game-like design to provide multiple avenues for engagement.	The "TOP AGENT" Leaderboard listed students in decreasing point total. The board can be customized to fit as many or as few agents as are enrolled in the program. Points are gathered by getting perfect scores on SRTs and completing extracurricular challenges.

Categories	uLearning Definition (Huang)	AREA154 Examples
Connections	Provides social-emotional interaction.	The ATN (agent-training notebook) is a dedicated paper-based notebook that students present to the “director” for evaluation. The interaction in class (or via email) provides opportunities for social-emotional connections between instructor and student. Examulations—the summative assessments of each case file—are done in groups. As with every chaotic event, one never can predict who will be around you, and these teams will need to work together to survive.
Site-central	A centrally located curriculum, a server-based internet-connected hub where all the learning content is located.	The site area: 154 is the parent domain for temple.area154.net (and several other subdomains that are in use by other instructional teams). The site is hosted by MidPhase.com, based in Chicago. All back-end management and SQL database management were created and managed by the primary investigator.
Any device	Curriculum can be accessed on any internet-accessible device (device-independent).	The site is typically accessed by Chromebook (district-provided) and by students’ cell phones. However, the site and its functions are also accessible via any web-based device.

The following results reflect the subjects' experiences and their perspectives on the types of confidence building experiences within the uLearning program. Each of the following tables displays the tabulated results from the interview. Not all of the ATV levels have responses. For example, in Table 13 there were no subjects that indicated CREs within the category of self-pacing and flexible deadlines. Each of the following tables reflects the ATV values for each uLearning category.

ATV: Self-paced.

As one might expect, there was little to no resistance to having flexible deadlines. Lewis (2010) noted that the adherence to deadlines appears to be more of a suggestion to multi-active people. When deadlines are harshly enforced, it can often lead to resentment and a reduction in productivity by a multi-active student. While not considered a point of opposition, a point brought up by Stu-M-7-14 is worth considering. He stated, “I like the flexible deadlines, but sometimes because I know I have more time, I put things off. I kinda procrastinate. I did it more so in this class.” These types of comments were also noted during the first year of the system’s implementation. Chronic procrastination touched on a possible design flaw that brought about a procedural change: developing an absolute deadline at the end of the case file. The new procedure would allow students to engage in some self-pacing without eliminating the concept that deadlines are real. This change provided the subjects with five to eight weeks to complete assignments. After the case file Examulation, the case ended, and everything was due. Stu-M-7-14 made those remakes with this zero-barrier policy in place. Many of the students viewed self-pacing as beneficial. However, some did feel that six to eight weeks was too much flexibility. The Affect Theme Value for *self-paced* was 3.8.

Table 13 Magnitude coding for category - Self-pacing and flexible deadlines

ATV Code	Number of participants coded at this value	Sample participant response for each ATV	Total for ATVs (Affect Value x Number reported)
1	0		0
2	0		0
3	8	"It didn't kill me with the deadline getting tremendous stress on you saying ask me, do then. At least I knew I had a little bit of lengthy period to fix it, helped that play a role in being able to get things done, or did it was it not good because it fed into procrastination? It really depends on the person."	24
4	7	"I would also be able to do everything on my own time, which even if we had a like with the, a deadline where we had turned in the work, it was still mostly at my own pace and my own time."	28
5	4	"You know, we're all human and we have bad and good days and we're not sometimes all in. And he just helped a lot because I, I get to work on my own time sometimes. And I know when I had it when I needed it to be done."	20
	Total responses 19/19	Total Magnitude for the category: **ATV value site-organization** (Total Mag/19):	72 **3.8**

Note: Affect Theme Values were calculated by taking the average of the total responses in a category. Restrictive experiences occurred in ATV ranges of 1 and 2. Neutral experiences are 3. ATV scores of higher than 3 represent confidence building experiences that have occurred.

<u>ATV: Anytime/anywhere.</u>

This theme did not receive any restrictive comments. No members of the study indicated that the ability to do work anywhere and at any time detracted from their learning experiences. As noted in the analysis, most of the students stated that they did not do schoolwork at home. It was unclear if this was due to not *wanting* to do work at home or not *being able* to do work at home. The majority of the subjects stated that if they did not finish work in class, they would do it the following day. The flexible deadlines could play a significant role in encouraging this behavior. Students also mentioned a preference for coming into the classroom at lunch or before school to complete schoolwork. That being said, the subjects who responded with an Affect Theme Value of 5 cited some extreme applications of system usage. One subject reported finishing an SRT in the car on the way to the airport—an emergency completion because grades were coming out soon. In another level-5 response, the subject was stuck at Walmart in the car. Being behind and needing to catch up, he facilitated his phone to catch up on his ATN with the website and PDFs' full support while waiting for his mother to finish shopping. The overall Affect Theme Value for this criterion was 3.4.

Table 14 Magnitude coding for category - Anytime/anywhere content access

ATV Code	Number of participants coded at this value	Sample participant response for each ATV	Total for ATVs (Affect Value x Number reported)
1	0		0
2	0		0
3	12	A: “I didn’t usually do it (chemistry classwork) at home.” Q: “What if you were behind and needed to catch up?” A: “I would do it in class or come in before school or lunch and do it.”	36
4	6	“What was mostly when I finish my work in class or I would have some spare time and just look through them because I, I believed everything was really interesting.”	24
5	1	“You know, we’re all human and we have bad and good days and we’re not sometimes all in. And he just helped a lot because I, I get to work on my own time sometimes. And I know when I had it when I needed it to be done.”	5
	Total responses 19/19	Total Magnitude for the category: **ATV value site-organization** (Total Mag/19):	65 **3.4**

Note: Affect Theme Values were calculated by taking the average of the total responses in a category. Restrictive experiences occurred in ATV ranges of 1 and 2. Neutral experiences are 3. ATV scores of higher than 3 represent confidence building experiences that have occurred.

<u>ATV: Fast feedback.</u>

The ability to receive immediate feedback on one's assessment or classwork was the highest-rated Affect Theme Value of those analyzed throughout the uLearning criteria. The limited amount of negative feedback came from subject Stu-M-8-16. He stated that the immediate feedback on the ATN was not so quick. He felt he was often told to wait to be helped due to the excessive demands the instructor was facing. Often that led to forgetting to have his ATN checked. The instructor was responsible for checking the ATN, and feedback could be considered slow. However, every person who had the experience of receiving feedback felt that it fostered a high level of self-confidence and self-validation. Feedback speed was limited because the assessment was not automated and was truncated by the instructor's availability. According to Huang and Springer-Verlag (2016), this interaction is not part of the uLearning platform. uLearning systems are generally autonomous and self-driving. The ATN checking procedure, however, was not uLearning design-compliant.

The other part of the AREA154 system that boosted immediate feedback—the SRT, or the Survival Readiness Test—was self-driving and operated on student demand. In the early iterations of AREA154, students were supposed to take these SRTs at home. Ideally, this would take full advantage of the flexibility of the uLearning system. However, according to the backend data on the site, roughly 50% of the students did not or could not complete the SRT outside of class. As a result, the SRT protocol was changed to reflect the budding observation that multi-active students and families tend not to complete work at home. From that point forward, students were provided with class time to at least start the SRT. Most would finish, while others never would.

Unfortunately, the Sensei LMS does not keep track of attempts made by the student. The app does not say whether the grade acquired was the result of one attempt or 23. The impact of this observation is discussed further in the results section. The overall Affect Theme Value for instant feedback was 4.5.

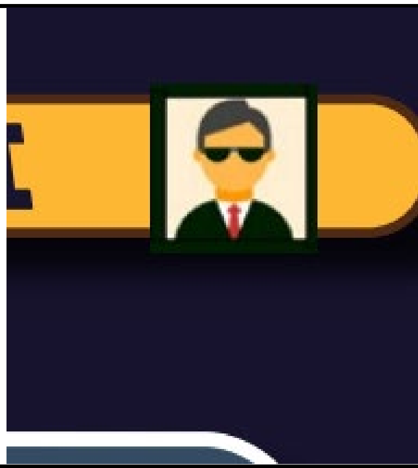
Table 15 Magnitude coding for category - Fast feedback on SRTs and ATN work

ATV Code	Number of participants coded at this value	Sample participant response for each ATV	Total for ATVs (Affect Value x Number reported)
1	0		0
2	0		0
3	2	A: "I feel good knowing that I have an A. It [the system] would tell you exactly what your grade was." Q: "And how many times did you take the SRTs typically?" A: "Like, let's say … five or six times."	6
4	6	"And to go back and do it again, I would like very much to see what I did wrong. Go back to my book and see if I can get it right, retake it. And if I got it right, I'm fine. If not, I just do it again."	24
5	11	"So being allowed to work past the self-doubt and be on your way to a more confident state while taking quizzes is amazing!"	55
	Total responses 19/19	Total Magnitude for the category: **ATV value site-organization** (Total Mag/19):	85 **4.5**

Note: Affect Theme Values were calculated by taking the average of the total responses in a category. Restrictive experiences occurred in ATV ranges of 1 and 2. Neutral experiences are 3. ATV scores of higher than 3 represent confidence building experiences that have occurred.

<u>ATV: On-demand instruction.</u>

Arguably, the idea of gaining information that you need *when* you need it and *where* you need it is the heart of the uLearning system experience. The network-centered location for all of the AREA154 content that provided 24/7 site access was the pedestal on which this uLearning criterion stands. Subjects repeatedly noted just how valuable this tool was for maintaining a sense of STEM class confidence. The apparent segregation between the higher-achieving and lower-achieving students was noteworthy. The higher-achieving students demonstrated a much higher appreciation for the “Director’s Icon”, Figure 11, and the “Media Icon,” Figure 12, presented here.



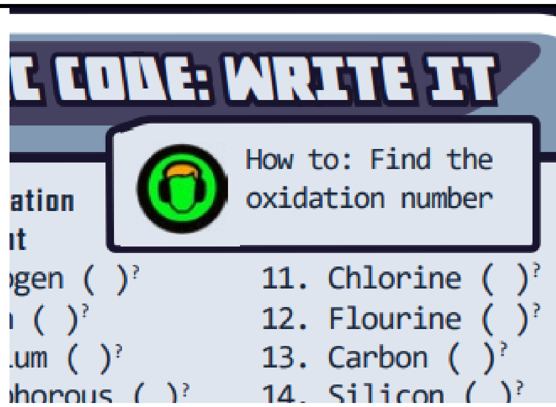


Figure 11 The “Briefing Icon”

Note: The “Briefing Icon,” a character dressed like a CIA agent, has a link to a video that describes exactly what the agent needs to focus on and produce inside their ATN for credit.

Figure 12 The “Media Icon”

Note: The “Media Icon” is the green circle that displays a person wearing headphones. This link takes students to specific tutorials on the subjects being taught in the section.

Every downloadable HyperDoc-style PDF on every case file came with these icons, which were there to support the learners when they needed particular information. As noted by some of the subjects, they rarely maintained 100% focus in class. A lot of “drifting” took place. The subjects indicated that having a place to go to discover directions or instructional assistance was notably helpful for building their confidence. The Affect Theme Value for this criterion was 4.4.

Table 16 Magnitude coding for category - On-demand instruction

ATV Code	Number of participants coded at this value	Sample participant response for each ATV	Total for ATVs (Affect Value x Number reported)
1	0		0
2	0		0
3	4	A: "It wasn't too frequently where I would use them. I was confused on something that I would that." Q: "Was that something that you would more likely do at home or at school?" A: "It was at home."	12
4	9	"So the fact that there was something there that guided you whenever you needed help was that was something that I used frequently."	36
5	7	"And that really helped the PDFs even gave, like, tools like a calculator. I don't know little websites like that. So you felt like everything you needed was in that that place. And that added to the sense of confidence. Oh, yeah."	35
	Total responses 19/19	Total Magnitude for the category: **ATV value site-organization** (Total Mag/19):	85 **4.4**

Note: Affect Theme Values were calculated by taking the average of the total responses in a category. Restrictive experiences occurred in ATV ranges of 1 and 2. Neutral experiences are 3. ATV scores of higher than 3 represent confidence building experiences that have occurred.

ATV: Real-world.

The ability to access the learning content that is most immediately relevant to the learner's world qualifies as real-world applicable. Huang and Springer-Verlag (2016) addressed this concept in connection to VR, with the implication that "real-world" could also be applied to the world relative to the user regardless of what "reality" they found themselves occupying. In AREA154, the real world was defined by what "could happen." All of the system content experienced by the subjects supposes a world that is in constant threat, and the learned content could be applicable at a moment's notice. It is a conditional sort of "real world." The direct applicability of the learning context is hypothetical and predicated on the possibility of an event happening in the real world. Students across the achievement spectrum demonstrated support for know-how that they could apply to situations that, in their reality, could happen any day.

Interestingly, although most of the subjects had shared information about the class, its learning content, and the skills gained, they also stated that their parents would not be likely to seek their help in the event of an emergency. According to interview data, most subjects believe that their perceptions of reality are often not shared by their parents. It is unknown to what extent this disqualification of the subjects' experiences affects their CBEs within the program. The Affect Theme Value for this criterion is 4.2.

Table 17 Magnitude coding for category - Real-world applications

ATV Code	Number of participants coded at this value	Sample participant response for each ATV	Total for ATVs (Affect Value x Number reported)
1	0		0
2	0		0
3	6	Q: "Do you think your parents or any other family you have would turn to you for input on what to do, knowing that you've been through this experience and that you've talked to them about it?" A: "Probably not."	18
4	8	"And it definitely helped me to me, I find it more engaging, think like it had a real-world application."	32
5	6	"Having always been fond of the drama in which the end of the world comes, I think the program just made me even more aware of the true possibilities of such a thing happening. I went home thinking about this quite often."	30
	Total responses 19/19	Total Magnitude for the category: **ATV value site-organization** (Total Mag/19):	80 **4.2**

Note: Affect Theme Values were calculated by taking the average of the total responses in a category. Restrictive experiences occurred in ATV ranges of 1 and 2. Neutral experiences are 3. ATV scores of higher than 3 represent confidence building experiences that have occurred.

ATV: Narrative.

The uLearning criterion of learning STEM subjects (or anything, for that matter) through an applied narrative was not very high on the priority list of uLearning criteria. Huang and Springer-Verlag (2016) described it as something nice to have but not an overly critical element. The subjects of the study might disagree with that notion. Not one student in the study presented any restrictive or even neutral data about how the AREA154 narrative affected their STEM class experience. Comments about this category were exceptionally positive, ranking it as one of the most significant elements of the entire experience. The narrative served as a part of the course that made the subjects "feel" about the content. An analysis of all of the interview transcripts in NVivo found that the word "feel" appeared 55 times in the section dedicated to discussing the "narrative" of the class. The application of the narrative story elements was not limited to the website and the PDFs. The ATN was developed specifically and thematically for the class. Subjects noted a sense of camaraderie when they saw students they did not know to pull out their ATN.

Subject Stu-F-7-10 noted, "Seeing the ATN in another class was, like, a sign that you and this person you don't even know have this connection." AREA154-themed images surrounded the classroom. Two 55" flat-screen TVs would commonly promote AREA154 imagery, post the live website, or show world-related data like volcanic hotspots or areas of high concentration of sulfur dioxide gases near Yellowstone National Park. The program narrative was very immersive and positively received by students, parents, and the administration. On multiple occasions, the district administration toured the room. However, that is not to say that students have not expressed concerns about the over-the-top class storyline in the three years of implementation. Only two students have opted to transfer out of the class—not because they did not find it interesting, but because they took it too seriously. The two students both noted concerns about how this class was exacerbating their anxiety issues. In this study, however, the subjects displayed no signs that the narrative was in any way curtailing their confidence. The Affect Theme Value for this criterion was 4.5. Table 18 displays how the value was produced.

Table 18 Magnitude coding for category - Learning through narrative

ATV Code	Number of participants coded at this value	Sample participant response for each ATV	Total for ATVs (Affect Value x Number reported)
1	0		0
2	0		0
3	0		0
4	10	"But I think it's like it was really interesting was like the whole set like really serious things that are like very useful in real life. I things like it's good to know. And it was really fun."	40
5	9	"Having always been fond of the drama in which the end of the world comes, I think the program just made me even more aware of the true possibilities of such a thing happening. I went home thinking about this quite often."	45
	Total responses 19/19	Total Magnitude for the category: **ATV value site-organization** (Total Mag/19):	85 **4.5**

* The application of a "narrative" covered the website, the design of the ATN, and the Examulation, which all applied to a single piece of content all year long. While observations from years of implantation development have indicated that some students have not cared for the thematic approach, none of the subjects reflected negative or even neutral opinions about their experiences in a thematic learning environment.

Note: Affect Theme Values were calculated by taking the average of the total responses in a category. Restrictive experiences occurred in ATV ranges of 1 and 2. Neutral experiences are 3. ATV scores of higher than 3 represent confidence building experiences that have occurred.

<u>ATV: Gamification.</u>

Gamification is an element that is listed as a uLearning criterion, yet it is not included in all uLearning systems. Interestingly, students were not as favorable about this part of the program. Since they are a population-age demographic often associated with being “gamers,” the assumption would have been that this element would have been better received. Most of the subjects replied with either neutral or slightly positive feedback about the system's gamification aspect. A few subjects noted slightly negative feedback experienced by not being on the Top Agent Leaderboard. In other words, they felt the Leaderboard at times to be restrictive in confidence building.

Interestingly, the students who made those comments were also three of the lowest five achievers in the subject group. On the opposite side of the spectrum, three subjects noted the compelling effect of gamification on their performance. One subject, Stu-M-9-15, stated that it was the primary thing that helped him earn a respectable grade. The Affect Theme Value for this criterion was 3.7. Table 19 shows the value assessment.

Table 19 Magnitude coding for category - Gamification

ATV Code	Number of participants coded at this value	Sample participant response for each ATV	Total for ATVs (Affect Value x Number reported)
1	0		0
2	2	"Never seeing my name on the list, sometimes, made me feel bad."	4
3	7	Q: "Did you pay attention to your own achievement points?" A: "Hmm, not too often. I really I really wanted to, but I don't know, I guess I just got caught up into, like, doing my ATN and, like, focusing on that."	21
4	6	"If I mainly got up there, I knew I was doing good and I know that I'm on top of things. And when my name would get lower, I'm like, okay, something's wrong. You need to start paying more attention and finishing it."	24
5	3	"Having always been fond of the drama in which the end of the world comes, I think the program just made me even more aware of the true possibilities of such a thing happening. I went home thinking about this quite often."	15
	Total responses 18/19	Total Magnitude for the category: **ATV value site-organization** (Total Mag/18):	66 **3.5***

**Only 18 subjects of the 19 total responded on the topic of gamification and its effect on their experience.*

Note: Affect Theme Values were calculated by taking the average of the total responses in a category. Restrictive experiences occurred in ATV ranges of 1 and 2. Neutral experiences are 3. ATV scores of higher than 3 represent confidence building experiences that have occurred.

ATV: Social connection.

The elements of social interaction within the system were intentionally limited for managerial reasons. No known formal protocol exists for how uLearning social connectivity should be represented in this sort of network. That being said, the collective social interactions within the AREA154 program were limited to in-class communications and the "Daily Post." Each day, the "Director" would post information on the site regarding the day and world training regimen or regional events that related to the case file. Students had the option to comment and reply to each post. Posting and replying to posts was not an encouraged practice. Some students experimented with it to ask others for help. However, those posts went unanswered by the agent community. After that, the practice stopped altogether. As such, the "Daily Post" was largely one-directional, as noted by the interview data. Some students would check in on progress and see what they had missed if they had been out, while others noted that they didn't look at the "Daily Posts" much at all. The Affect Theme Value for this criterion was 3.8. Table 20 demonstrates how the ATV was derived.

Table 20 Magnitude coding for category - Social connection

ATV Code	Number of participants coded at this value	Sample participant response for each ATV	Total for ATVs (Affect Value x Number reported)
1	0		0
2	0		0
3	6	Q: "The daily posts, did you read them or interact with them?" A: "No."	18
4	8	Q: "Did you use the daily posts on the site?" A: "Yeah, I think I helped." Q: "Did you frequently use them, semi-frequently use them? How frequently do they become part of your classroom experience?" A: "Yeah. Probably two or three times a week." Q: "Would you say that was maybe more on-demand or just out of curiosity or out of habit?" A: "I think is more out of curiosity. Like, what are we doing today?"	32
5	2	"If you remember, there was a two-week period that I was out. I was sick. Every day, I would check the site and the post thing to see what we were doing. It was the only class I could do that with."	10
	Total responses 16/19	Total Magnitude for the category: **ATV value site-organization** (Total Mag/16):	60 **3.8***

**Only 16 subjects of the 19 total responded on the topic of gamification and its effect on their experience.*

Note: Affect Theme Values were calculated by taking the average of the total responses in a category. Restrictive experiences occurred in ATV ranges of 1 and 2. Neutral experiences are 3. ATV scores of higher than 3 represent confidence building experiences that have occurred.

ATV: Central site

The comments about the site, the level of organization, and the deployment of content, assessments, and gamification elements would have been nearly impossible without a centralized location in which to put all of the site data. The WordPress-powered site hosted by MidPhase provided the server space for the site. The videos sourced from outside locations were downloaded and stored on the AREA154 servers. Students behind the SJUSD firewall were often unable to use links made directly to videos on YouTube or other video-hosting sites due to district security restrictions. The filtering and blocking of content were notably frustrating for everyone involved. The subjects' feedback on this category reflects an active effort to localize every support video so all the support media can be accessed all the time. While some external links continued to connect to sanctioned websites, and a couple of videos may exist online that are not on the local server, but none-the-less the vast majority of the learning content does not need the external internet. Subject Stu-F-7-13 lamented that learning in some other classes was spread out in so many directions. She was not the only person to pan out how other teachers spread the learning content over the internet. The subjects' apparent frustration in other classes may be what prompted the positive reactions to the concept of content centralization. The Affect Theme Value for this criterion was 4.2. Table 21 demonstrates how the ATV was derived.

Table 21 Magnitude coding for category - Centralized network resources

ATV Code	Number of participants coded at this value	Sample participant response for each ATV	Total for ATVs (Affect Value x Number reported)
1	0		0
2	0		0
3	0		0
4	11	"What it was made everything a lot easier because I had all the information that could help me with the quizzes and tests, and I would also be able to do everything on my own time, which even if we had a like with the, a deadline where we had turned in the work, it was still mostly at my own pace and my own time."	44
5	8	"Having everything located (and organized!) in one place is always preferred to opening 10 different tabs and becoming a confused mess. The clarity and centralization was one thing every other teacher should take notes on including."	35
	Total responses 19/19	Total Magnitude for the category: **ATV value site-organization** (Total Mag/19):	79 **4.2**

Note: Affect Theme Values were calculated by taking the average of the total responses in a category. Restrictive experiences occurred in ATV ranges of 1 and 2. Neutral experiences are 3. ATV scores of higher than 3 represent confidence building experiences that have occurred.

ATV: Any device

Huang and Springer-Verlag (2016) noted that a uLearning network should be accessible by various devices to be truthfully labeled as ubiquitous. However, as a website, AREA154 was accessible by any network device connected to the internet. During the building phases, the temple.area154.net website was successfully tested when loaded on gaming platforms, iOS devices, Android devices, tablets, phones, smart TVs, and an internet-connected refrigerator. Despite the broad base of devices that could host the AREA154 experience, very few of the subjects found themselves accessing the site on anything but their district-provided Chromebook and possibly their phone. In one extreme example, a student took a quiz on an Xbox. However, Stu-M-9-15 was the only known student to have ever done this. Overall, the open platform seems like a perk, but evidence suggests that it plays a relatively insignificant role in the students' confidence building experiences. The Affect Theme Value for this criterion was 3.4**.** Table 22 demonstrates how the ATV was derived.

Table 22 Magnitude coding for category - Any device

ATV Code	Number of participants coded at this value	Sample participant response for each ATV	Total for ATVs (Affect Value x Number reported)
1	0		0
2	0		0
3	12	Q: "Did you ever attempt to access the website through something besides your Chromebook?" A: "No."	36
4	5	"I remember those times where, I mean and if you remember [student's name] and we would walk home. He would forget, like, what do we do in class? I would get my phone because I had I had it bookmarked on my phone too."	20
5	1	"My phone got taken away, we because 'reasons' and I really needed to finish an SRT. So my older brother had me do it on his Xbox. Forgot that thing has internet on it."	5
	Total responses 19/18	Total Magnitude for the category: **ATV value site-organization** (Total Mag/18):	61 **3.4***

**Only 18 of the 19 subjects provided feedback on this uLearning criteria.*

Note: Affect Theme Values were calculated by taking the average of the total responses in a category. Restrictive experiences occurred in ATV ranges of 1 and 2. Neutral experiences are 3. ATV scores of higher than 3 represent confidence building experiences that have occurred.

Revision and Visualization

Phase II focused on the subject's experiences within the uLearning system (AREA154). Their experiences reflect what they could recall from across the course of the 2019–2020 school year. Each of the categories was derived from the uLearning criteria presented by Huang and Springer-Verlag (2016), which also guided focused code development. In Phase II, the researcher aimed to understand the effect of uLearning design on confidence building experiences. The Affect Theme Values below summarizes the overall relationship each uLearning design criterion had on the participants.

After two phases of analytical cross-checking, the grounded theory grew to explain how the uLearning system (as experienced through AREA154) provided the means to build student confidence and success in STEM-related subjects. Figure 13 illustrates the developing theory in visual form.

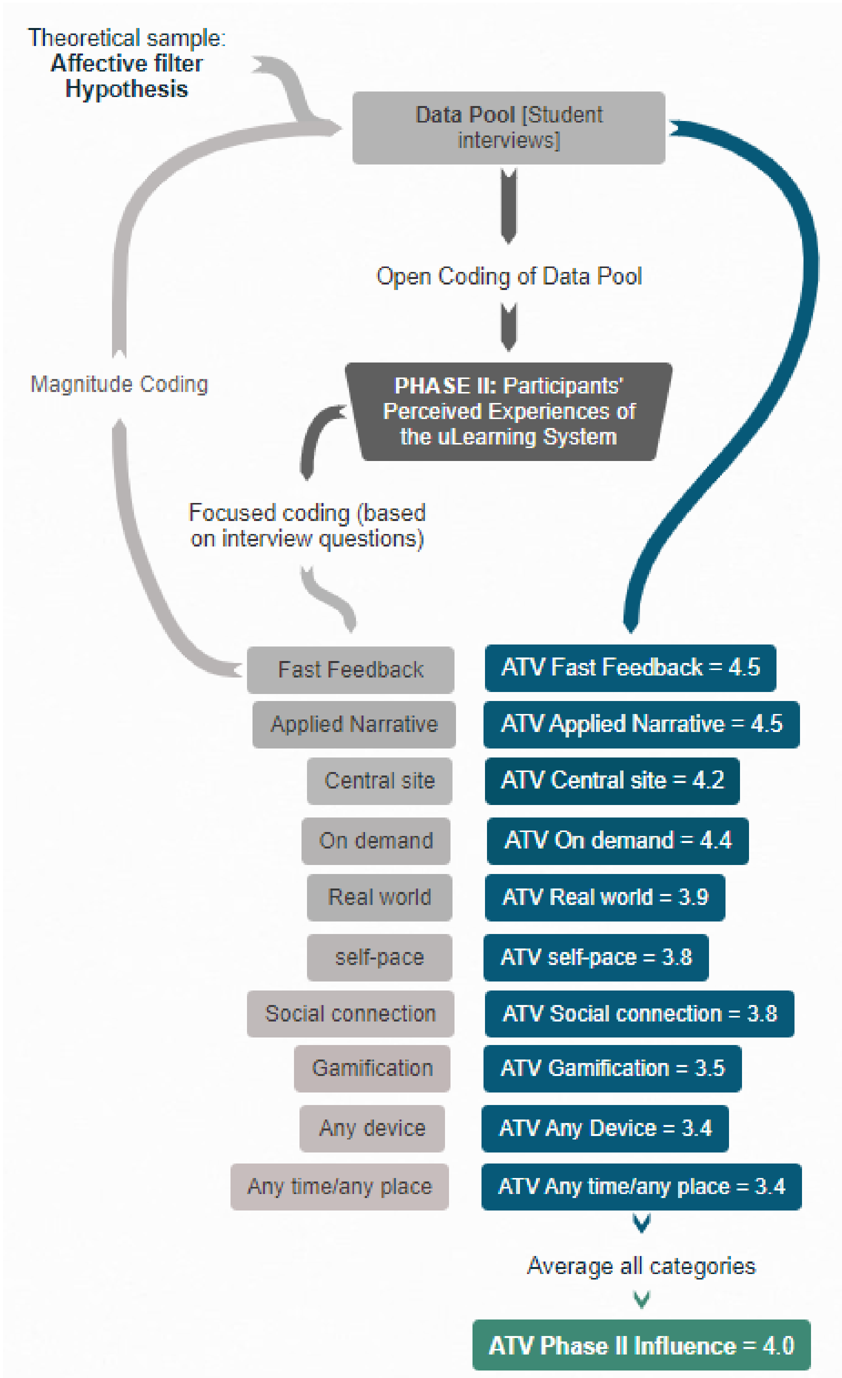


Figure 13 The visualization of Phase II Affective Theme Values

Note: The diagram illustrates the data analysis process from the open coding of the data into major organizational phases, from that phase to the focused coding into categories that reflect the questions asked to the students. Once formed the categories were magnitude coded based on the various responses provided by the participants reflecting their various responses to that category. A numeric theme value was provided to each category once all of the participants responses were summed and averaged. An overall phase ATV is the result of the summation and averaging of the individual category ATVs.

Phase III: Categorization on Experience of Non-uLearning System

The AREA154 experience exemplifies uLearning design principles. However, the study must also examined program factors that might enhance the uLearning system or detracting from it that lie outside of the influence of the instructional designer. The purpose of this study is to identify a theory that could potentially explain the decrease in failure rate and the observed success experienced in the first three years of the program. Phase III analyzes factors affecting success and confidence building that are not categorized as part of the traditional uLearning system. Educational success is very nuanced and influenced by factors that can vary widely from home to home.

The influence of the instructor cannot be ignored in an analysis that seeks to generate a theory explaining the past-reported success of the AREA154 system in which the teacher, content designer, and technology support were not involved. Figure 14 illustrates the categories that resulted from the focus coding of Phase three.

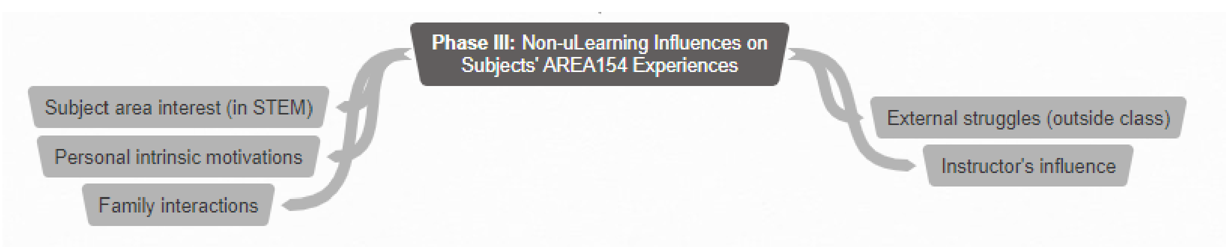


Figure 14 Categories emerged from focus coding of Phase three

Non-uLearning categories derived from the student data considered how factors outside the students' uLearning experience could influence subjects' direct interaction with the program. A list of non-uLearning themes from the interview data and the Aeries student-management system are listed below.

Table 23 Code descriptions and the uLearning criterion for each

Category	Definition	AREA154 Impact Areas
Subject-area interest	Subject area interest was ascribed to any inherent or innate interest in STEM that would, by itself, create confidence building experiences. Oppositely, it could be argued that aspects of AREA154 could restrict confidence because of its additional complexities.	If the subject has a natural inclination for science, a possibility exists that some elements of uLearning might interrupt the interest of a pure subject.
Personal-learning motivations	Learning motivations were ascribed to emotionally fulfilling parts of the curriculum that provide the momentum for students to have confidence building experiences (CBEs) vs. confidence-restricting experiences (CREs).	A student motivated by grades and a high GPA could influence the Affect Theme Value of the AREA154 system. To avoid giving credit to the system that is not due to the system, subject responses should be analyzed to assign evidence-based credit to any Affect Theme Value earned.
Family interactions	Familiar interactions are ascribed to any effect that family, or extended family, may have on the subjects' confidence building or -restricting experiences.	Subjects occasionally noted that they would share interesting topics with family members. This interaction could build or restrict the confidence of the subject in the program. Additionally, family activities or priorities could also restrict student success or STEM confidence. These factors are largely outside of the uLearning system's influence but can substantially affect the subject's perceptions of the system or performance in the class.
External struggles	Sources of struggle were ascribed to any factor outside of the uLearning process. Family and personal issues that detracted from the experience were assigned numbers of 1 and 2 to account for their restrictiveness. Any struggle that appeared to be aided by some portion of the uLearning system was provided a value of 4 or 5. Values of 3 indicated the presence of no external struggles that would restrict class experiences.	All students have the potential to have negative and success-restricting experiences that are outside of the influence of the AREA154 program, yet still affect their success within the program. This theme analyzed how the uLearning system played a role in addressing external factors that could restrict learning.

Category	Definition	AREA154 Impact Areas
Instructor influence	The instructor-influence theme reflects student interviews that note the impact the instructor had on the STEM uLearning experience, including but not limited to the instructor's demeanor, personality, discipline policies, professional experiences, and the fact that the instructor was the developer of the AREA154: Apocalypse Division uLearning program.	A good teacher can arguably make any system come to life. As such, the instructor's influence over the system's performance must be taken into account. In face-to-face environments, no academic program works alone, and the influence the teacher has on the program's success can add substantially to CBEs or equally contribute to the addition of CREs.

The following list of tables displays the findings collected from the interview transcripts.

The codes generated categories about students' lives outside of the uLearning system that could still be considered part of the AREA154: Apocalypse Division experience.

ATV: Subject area interest

Observational experience over the three-year implementation period pointed to several examples of students who did not care for the class content or how it was designed. Statements expressing such sentiments were rated with an Affect Theme Value of 1. The phrase, "Science just isn't my thing," or other variations of this "mildly restrictive" statement, received an Affect Theme Value of 2. Statements reflecting a favorable view of science or STEM classes were given Affect Theme Values above 3 and up to 5.

Interestingly, no subjects indicated any values below 3. Observational data regarding some of these subjects (included in the student profiles in Phase IV) would suggest that they might have an interest in STEM, though that interest does not appear to be intense enough to inspire productivity. One of the revealing points of this category centers on the observation that for this subject group, subject-area interest played a role in holding students’ attention and possibly engagement, but not the number of gradable artifacts. Three of the five subjects who responded in a way that warranted an Affect Theme Value of 5 had some of the lowest overall grades in the class. While the overall category ATV was 4.0, this finding was puzzling. It brings up the notion of learning and how learning is evaluated. Two of the subjects with an ATV of 5 in this area actually demonstrated interest in the subject outside of class. One of them (Stu-M-4-3) not unexpectedly took an engineering elective the following year and also built a smelting pit to run the thermite reaction in his backyard, something he had learned in one of the AREA154 case files. This subject scored moderately well in the class but not at the top.

Similarly, the second student kept his ATN, finished course content that he had not completed during the school year, developed an interest in electronics, and has continued working with electronic devices since. However, subject Stu-M-7-17 had the third-lowest overall grade in the class. A caveat should be made on the calculation of this ATV. Grades were determined by production, and production tendencies were considered to be a very linear-active trait. Lewis (2010) predicts that interest will influence linear-active students' grades because they are psycho-socially programmed to produce. That might explain the mixed findings between subject grades (as seen in Phase IV) and indicated interest. The Affect Theme Value for this category is 4.0. Table 24 demonstrates how the ATV was derived.

Table 24 Magnitude coding for category - Subject-area interest

ATV Code	Number of participants coded at this value	Sample participant response for each ATV	Total for ATVs (Affect Value x Number reported)
1	0		0
2	0		0
3	7	Q: "Did the AREA154 experience interest you in taking another STEM course?" A: "Maybe, I don't know."	21
4	5	"Pertaining to this class did peak my interest into more STEM related courses- like earth and space science, marine biology etc…"	20
5	7	Q: "So what science classes are you taking this year?" A: "I'm taking AP advanced chemistry." Q: "That's a tough class; did you always plan on taking it?" A: "No, I actually wasn't really into science at all until this class."	35
	Total responses 19/19	Total Magnitude for the category: **ATV value site-organization** (Total Mag/19):	76 **4.0**

Note: Affect Theme Values were calculated by taking the average of the total responses in a category. Restrictive experiences occurred in ATV ranges of 1 and 2. Neutral experiences are 3. ATV scores of higher than 3 represent confidence building experiences that have occurred.

<u>ATV: Personal motivations.</u>

Because personal motivations play an influential role in a student's success in school (Krapp, 1999), attention should be paid to how they may have influenced subjects' CBEs in AREA154. The following analysis of the subjects' motivations was calculated differently than the previous category analysis examples. A student who was entirely driven by grades would demonstrate an Affect Theme Value of 1, essentially signifying that the uLearning AREA154 experience was a lot of noise that got in the way of getting the work done for a grade. An Affect Theme Value of 5 would be assigned to statements demonstrating that AREA154 and its subsequent uLearning components were the primary motivating force behind the subjects' level of perceived achievement. The following tables present the collective data that reflects the influence of each of these noncategorical characteristics. The Affect Theme Value for this category was 3.9. Table 25 demonstrates how the ATV was derived.

Table 25 Magnitude coding for category - Personal intrinsic motivations

ATV Code	Number of participants coded at this value	Sample participant response for each ATV	Total for ATVs (Affect Value x Number reported)
1	0		0
2	1	"It's not like the course was boring. But if I don't get As, my mom is, you know, like, all over me."	2
3	4	A: "In the first semester, I was, uh, not into [motivated by] school. More like into other things." Q: "What sort of other things?" A: "Like, just having fun, partying." Q: "Why only first semester? What happened?" A: "I learned about the evidence for aliens on Earth in the case file. It was at that point that I was interested. It was after that I started doing my work."	12
4	8	Q: "The class was themed, and the class had a narrative, and a goal made you want to learn more. Was that a motivating factor." A: "Yes, for sure."	32
5	5	"Like, it's interesting to learn all the information we're told, and you get the chills, and you get up, and you just want to, like, learn."	25
	Total responses 19/18	Total Magnitude for the category: **ATV value site-organization** (Total Mag/18):	71 **3.9**

**Only 18 of the 19 subjects had responses on this category.*
Note: Affect Theme Values were calculated by taking the average of the total responses in a category. Restrictive experiences occurred in ATV ranges of 1 and 2. Neutral experiences are 3. ATV scores of higher than 3 represent confidence building experiences that have occurred.

<u>ATV: Family interactions.</u>

In general, family interactions between the subjects in the study and their families did not appear to affect CBEs in any particular way. The determined Affect Theme Value of this category was neutral: ATV = 3. Subjects' statements about interactions with their parents strongly suggested that family interactions restricted confidence. For example, evidence of intentional or unintentional subversion of subjects' interests emerged in how they responded to family interactions questions. As Stu-M-7-9 mentioned, he believes that his success might feel threatening to his parents. Alternatively, as mentioned in Chapter Two, restrictive behavior suggests that parents may subvert education because they start to feel detached from their children. Whether this holds true or not with Stu-M-7-9 is unknown. Not surprisingly, the language barrier played a role in subjects' willingness to share their uLearning experiences with their families.

On the opposite end of the support spectrum, some subjects' parents demonstrated support for their AREA154 experience to the point of wanting to attend the class themselves. Interestingly, though, regarding the subjects who responded to this topic with Affect Theme Values of 5, there is no consistency in achievement for this value. The two subjects whose comments were assigned values of 5 were on polar opposite ends of the achievement spectrum. In contrast, subjects who indicated a restrictive experience with their family were all in the middle or toward the bottom of the overall class grade ranking. The Affect Theme Value given to this category was 3.0. Table 26 demonstrates how the ATV was derived.

Table 26 Magnitude coding for category - Family interactions

ATV Code	Number of participants coded at this value	Sample participant response for each ATV	Total for ATVs (Affect Value x Number reported)
1	3	"There's like times where I want to get my homework done. It's like I think that my parents don't really care about my grades? I get home and it's like, now it's my job to take care of my little brother, clean my room, chores, and whatever. Make her [mom's] life easier, I guess. They both dropped out of high school, so, I don't know. Maybe they don't like it when I do better in school than they did."	3
2	4	"As soon as I got home it was all about chores, helping my brother and sister … basically just helping around the house. It was all fine and whatever, but it meant that I had to do school stuff later. A lot of times I was tired, ya' know? Sometimes I didn't finish school stuff. I needed a break or just went to bed."	8
3	5	"My parents don't really speak English well. So don't talk to them about it. I wouldn't even know how to explain it."	15
4	4	"We were talking about, like, the alien thing that we went over in class. She's [mom] is really interested in that sort of stuff."	16
5	3	"I was talking to my dad, who is really into this sort of stuff, and he asked me if I could come to the class, too."	15
	Total responses 19/19	Total Magnitude for the category: **ATV value site-organization** (Total Mag/19):	57 **3.0**

Note: Affect Theme Values were calculated by taking the average of the total responses in a category. Restrictive experiences occurred in ATV ranges of 1 and 2. Neutral experiences are 3. ATV scores of higher than 3 represent confidence building experiences that have occurred.

ATV: External struggles

All students struggle, some more than others. This category arose from the data that noted codes associated with areas of social-emotional struggle. The focus here will be to assess the role that the AREA154 uLearning system played in that struggle or how it potentially alleviates the struggle. The findings indicated that a notable effect on the student's performance occurs when life outside the classroom applies emotional stress to the student. Almost half of the subjects did not overtly state that they were experiencing any external sources of struggle (beyond what they considered normal). Therefore, they have ascribed an Affect Theme Value of 3, indicating that this category had no outside effect on their experience in class. However, about a third of the subject group stated that they were experiencing some form of stress. Two subjects, both male and both at the very bottom of the grade ranking, said they were in the middle of emotional issues that dominated their school experience. An argument could be made that this external factor is responsible for their poor performance. At the time of the interview, both of these subjects stated that they were now in "a better place" and were again enrolled in science classes—both subjects had far better grades than they had earned in the previous year in AREA154. Overall, the external factors category analysis provided a means of assessing the influence that uncontrollable life events could have on the overall Affect Theme Value for building success and confidence. Though the AREA154 uLearning system did appear to help address some of these challenges, much of what the students experienced was beyond this study's scope. The Affect Theme Value assigned to this category was 2.8. Table 27 demonstrates how the ATV was derived.

Table 27 Magnitude coding for category - External struggles

ATV Code	Number of participants coded at this value	Sample participant response for each ATV	Total for ATVs (Affect Value x Number reported)
1	3	"I was going through stuff. My whole world was upside down. Sometimes I had to leave class and walk. It was like … I can't even, right now."	3
2	4	"I think part of the problem is that I'm pretty lazy. I'm sure my struggles are kinda my own fault."	8
3	8	*Students had either indicated they had no struggles or had not stated that they had external struggles.*	24
4	3	"I didn't want to do the work because I was like, what does this have to do with chemistry or anything? And then [the instructor] would show how all the stuff in the class goes back to chemistry. Pretty cool."	12
5	1	A: "As you know, I struggled with some pretty bad social anxiety. It a strength and a weakness." Q: "How do you mean?" A: "The need to feel socially withdrawn, like, makes focusing easier. But only in some classes. This was one of them. I felt, like, I could relax a little and do my work and enjoy the crazy stuff we did in AREA154."	5
	Total responses 19/19	Total Magnitude for the category: **ATV value site-organization** (Total Mag/19):	52 **2.7**

Note: Affect Theme Values were calculated by taking the average of the total responses in a category. Restrictive experiences occurred in ATV ranges of 1 and 2. Neutral experiences are 3. ATV scores of higher than 3 represent confidence building experiences that have occurred.

<u>ATV: Instructor impact</u>

The categorical analysis for instructor influence will be approached a bit differently than the other Affect Theme Value evaluations. As previously mentioned, these students' instructor was the originator, designer, and implementor of the AREA154: Apocalypse Division uLearning system. Additionally, the instructor has multiple national teaching awards, is a college professor who instructs educational technology, and has 24 years of in-classroom instructional experience. The instructor was highly skilled, and an instructor's abilities played a critical role in a program's success. This analysis category attempted to collect data concerning the system's viability without the person who built the program teaching the course. Is it possible that another person could lead students through the curriculum and still provide confidence building experiences? Initially, the subjects responded with statements indicating that another instructor could not run the system. Follow-up questions then probed further, asking subjects if practical training would be enough to allow another instructor to use the program effectively or at least acceptably well. Many of the subjects agreed that with effective training, this could be possible. In her testimony, Stu-F-7-10 stated that different highly-skilled science or chemistry teachers who were willing to immerse themselves in the program narrative and "explore it with the students" would stand a much better chance of succeeding.

Such answers suggesting no one but the original instructor could produce similar findings received an Affect Theme Value of 1. Conversely, an Affect Theme Value of 5 was associated with student statements that seemed confident that with the right training and set of personal traits, the program could absolutely be replicated with similar CBEs. This category was given an ATV of 2.5. Table 28 demonstrates how the ATV was derived.

Table 28 Magnitude coding for category - Instructor influence

ATV Code	Number of participants coded at this value	Sample participant response for each ATV	Total for ATVs (Affect Value x Number reported)
1	5	"You created that website. But that doesn't mean it's not the same thing. You are the website. You have all the information. You are like the guru of it, like you have all the details."	5
2	6	Q: "Do you think that the Area 154 program Apocalypse Division could be taught successfully by a different teacher?" A: "No. Eh, not the same way."	12
3	3	"Our class was pretty, like, do it yourself. It wouldn't feel the same, that's for sure, but I don't know. I actually don't know if it would work."	9
4	3	"I think so, because I think everything is there in the videos and, you know, like the PDS and everything. I think it would be possible."	12
5	2	Q: "Could the AREA154 experience be taught by another teacher?" A: "Yes, however, you guys [current and any future teachers] need to have a very similar characteristics. And that is to be to make the ability to make it exciting, the way you talk about it, you put yourself in that actual situation. And it's someone that has	10
	Total responses 19/19	Total Magnitude for the category: **ATV value site-organization** (Total Mag/19):	52 **2.5**

Note: Affect Theme Values were calculated by taking the average of the total responses in a category. Restrictive experiences occurred in ATV ranges of 1 and 2. Neutral experiences are 3. ATV scores of higher than 3 represent confidence building experiences that have occurred.

Revision and visualization

After three phases of analytical cross-checking, the grounded theory took on a new shape. It now includes information concerning subjects' testimonies regarding noncategorical influences that affected their STEM learning experiences. Figure 15 below presents the current development of the grounded theory with three phases completed.

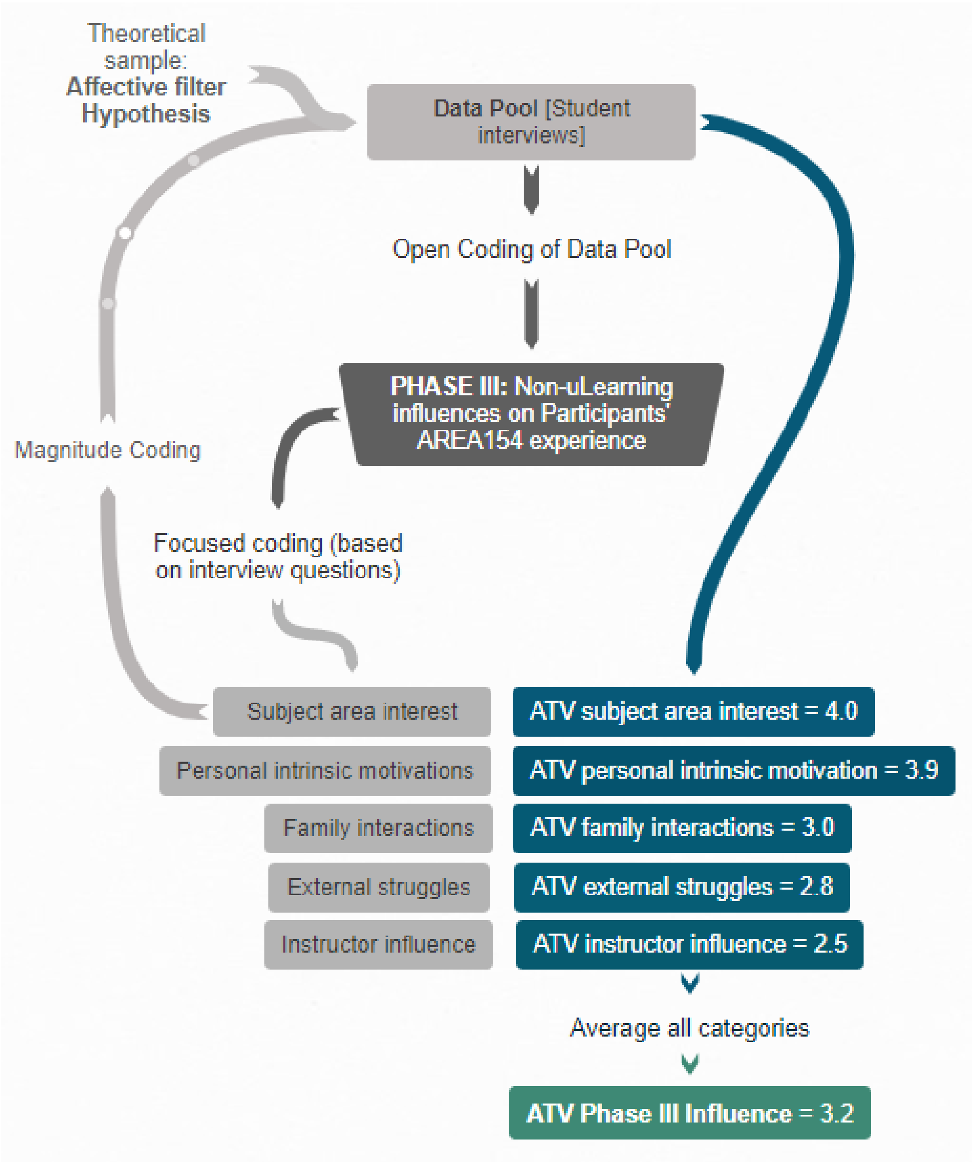


Figure 15 The visualization of Phase III Affective Theme Values

Note: The diagram illustrates the data analysis process from the open coding of the data into major organizational phases, from that phase to the focused coding into categories that reflect the questions asked to the students. Once formed the categories were magnitude coded based on the various responses provided by the participants reflecting their various responses to that category. A numeric theme value was provided to each category once all of the participants responses were summed and averaged. An overall phase ATV is the result of the summation and averaging of the individual category ATVs.

Phase IV: Multi-Active Behavior and Achievement Validation

The study's foundation rests upon the assumption that uLearning systems can prove beneficial to people who display multi-active psycho-social behaviors. Hispanics, according to Lewis (2010), are described as highly multi-active. Phase IV attempts to understand the subjects' identities, assess their multi-active behavioral traits, and present accessible, transparent data to validate student testimony about their perceptions of success.

<u>Student profiles</u>

Nineteen students participated in the study. Eighteen were interviewed over Zoom, and one responded via a question-and-answer format through district email. Phase IV aimed to validate the assumption that the students who self-identify as Hispanic (American Hispanic) still retain the multi-active psycho-social behavioral traits that Lewis (2010) observed. The subject profiles collected data on all of the following:

- the subjects' fall and spring grades for the 2019 and 2020 semesters,
- all progress report grades demonstrating a path of achievement,
- the final spring semester grade in comparison to spring semester grades for all of the core subject classes,
- subjects' average login and usage time,
- memos concerning the subjects' in-class performance and behavioral tendencies during the 2019–2020 school year,
- data regarding subjects' enrollment in a STEM class the following year,
- memos concerning the interview observations and context of the interview,
- a list of codes about the interview data of each subject,

The student profile data are lengthy and detailed. Much thought and consideration were given about whether or not to maintain the subjects' profile data's existing continuity. After reading and observing the structure of several other grounded theory dissertations (Clapham, 2012; Catherall, 2017; Greenhaus, 2014), keeping the data visible, transparent, and aligned with the theory development offered clear benefits. As Catherall (2017) described, GT provides a tour of evidence with twists and turns that let the readers discover the theory as it evolves. Phase IV findings provide support for the other three phases by supplying a cross-check to the subjects' perceptions. Findings here address research question two by seeking to verify participants testimonies about additional. All processed data regarding these findings can be found in Appendices I, J, and K.

Academic performance and cultural findings

Academic improvement was analyzed by code frequency and broken down by achievement level. Viewed this way, some clear trends arise. In every top-grade category between A and D, a minimum of 71% of the subjects reported AREA154 as their top grade of all core subjects. In every category, a minimum of 87% of the subjects said their grades in AREA154 were better than those for their freshman biology or Biomed I class. In the A and B categories, a minimum of 71% of the subjects stated that their grade improved in the second semester.

Sections reflecting multi-active behavioral traits demonstrated The multi-active interview Q&A confirmed that a minimum of 87% of the subjects in *all* categories self-ascribed multi-active behaviors. Only the A category self-ascribed behavioral traits that were linear-active, indicating a higher degree of cultural integration into the U.S. educational system. As the grades became lower, the number and frequency of multi-active traits increased, possibly reinforcing the supposition that the multi-active and linear-active cultures are psycho-socially incompatible. The indications that a student may be having trouble in the subjects become notable with the lower grades. There is some evidence to suggest that their low grade in the class may have resulted in part from domestic unrest. In the case of the one student who did not self-identify as multi-active, although his actions in class and the interview session would suggest strong multi-active influences at home, he was part of a military family. The subject was in his second year of ROTC during the time of the study (Participant Stu-M-4-3 – His profile information can be found on table I-4 in Appendix I). Sections reflecting login and session time at school and home show the login frequency and the duration of the login time both at home and at school drop, indicating that students are unwilling or unable to log into the class site when at home. After the focus coding Phase four, two categories emerged from the structured questions asked to the participants about their state of confidence or more specifically their expectancy in STEM. The categories reflected two areas of reflection. The first was the comparison between their freshman year bio class and AREA154 (about half way through the year). The second was to express their level of confidence on STEM at the end of the Spring semester. Figure 16 illustrates the two categories.

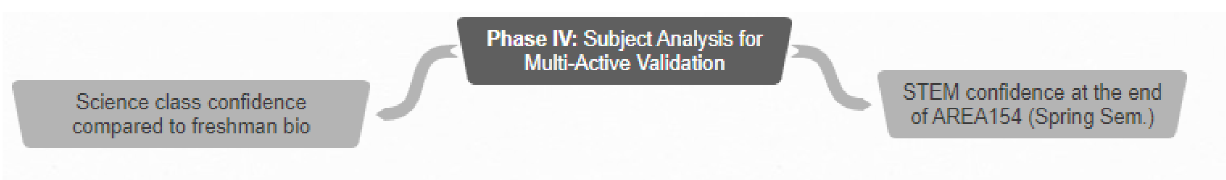


Figure 16 The results of focused coding for Phase four

Table 29 presents the coding findings as categories developed from interview transcript-coding sequences. These categories collectively encompass elements that affected subjects while they were participating in the AREA154 uLearning experience.

Table 29 Category, the meaning, and the effect on AREA154 experiences

Category	Definition	AREA154 Impact Areas
Con-I-Fresh	Perceived STEM confidence during the year prior to the uLearning system. In most cases, this was freshman biology. However, for two of the subjects, BioMed I was their freshman science experience.	This category seeks to identify examples where AREA154 is influential in students' perceptions. The analysis will focus more on whether the program did or did not have an impact and to what degree.
Self-con-post	Perceived STEM confidence after the uLearning system.	This category seeks to identify areas of the AREA154 construct in which subjects stated that they have higher levels of CBEs and those responsible for restricting their STEM confidence (CREs).

The Table 30 assesses each individual subject's response to their confidence level after having experienced the system for one academic year. Essentially, subject confidence ascribed to the program will be assigned an Affect Theme Value, like before. Subjects who indicated a high number of CREs would be represented by 1. Conversely, subjects who reflected a high amount of CBEs will be assigned a value of 5. In addition to the confidence data (any subject data that indicated an experience of high confidence), the corresponding subject area or uLearning feature was added to the subjects' confidence statements. Table 29 represents the student's general perceptions of how the AREA154 uLearning program affected their STEM experiences.

Table 30 Magnitude coding for self-evaluated confidence change post AREA154

Participant (Ranked by averaged course grade)	Interview Response	ATV
Stu-F-6-1	"The idea that I could be able to save someone's life. That was both confidence building and scary. But it was a good thing."	4
Stu-F-7-2	"At the end of the year, felt pretty successful and confident."	4
Stu-M-4-3	"I would still do the work at home and I still have that confidence, but I wish I had more confidence from what I was writing down in class. But at the end, best science class I've ever had."	5
Stu-F-8-4	"Yeah, when I took one of the first SRTs because I knew I believed there was going to be a lot easier. But it wasn't also because I wasn't using my notes, but once I started using the notes [ATN] and actually taking notes of the presentations and everything else, it was a lot easier, like the second time I took it [SRT] I did way better. It was an easy system after that."	4
Stu-F-6-5	"Once you got in the program. I feel like I think I caught on to the lessons faster, and I'm not sure why, I think because the way it was presented made it more interesting to pay attention. I think."	4
Stu-F-7-6	"There was some struggle at first, because … it's new, not normal, like, at all … once I figured out the system, I felt like with some effort I could get the grade I need."	5
Stu-F-9-7	"You gave us a list of things to find a way to find it, but you didn't make it super easy … And those added to your level of confidence of like, hey, I can do this and I don't need anybody else to help or I feel like I'm independent and I could do this on my own."	5
Stu-M-9-8	"I think it is because the way that you're teaching it, because you were like actually engaging in what we were doing and like just like the platform that you had everything on, because since everything was on one website and everything."	4
Stu-M-7-9	"I felt better at science at the end of the year. I've never had a class that made me think so much. My grade could have been better, but what mattered was how it opened my eyes to how, you know, like the bigger picture, stuff that I've felt for a long time. But this class made me think. Wasted a lot of hours staring at my ceiling thinking about stuff from that class."	5
Stu-F-7-10	Q: "Would it be fair to say, that you feel more confident and successful in STEM subjects now?" A: "Yeah, absolutely, but I can say at the end, like I had the hang of it and what to do."	5
Stu-F-8-11	Q: "It sounds like you say you feel pretty confident when you compare that [AREA154] to, let's say, previous experiences?" A: "Yeah, for sure."	4

Participant (Ranked by averaged course grade)	Interview Response	ATV
Stu-F-8-12	"A lot of confidence, especially when, okay, you would look at it and you would think, 'I don't know any of this and I don't know how I'm going to learn it, and it's complicated,' but then when you just sit down and listen and you get the hang of things, you know, you do it for yourself and then you get it right. You just have a lot of confidence and then want to do it again and you wait for the next one."	5
Stu-F-7-13	"All in all, I would say my confidence in science skyrocketed throughout the year -especially since everyone always has a chemistry horror story to tell."	5
Stu-M-7-14	"Then looking back, you're like, do I feel more confident, like I can do this stuff? There for me, and I feel more confident and I feel more curious about other things, chemistry, biology, I feel more curious."	4
Stu-M-9-15	"This was the best grade I had all year. I think it was the best grade I had in all of high school, except for maybe, like, PE."	5
Stu-M-8-16	Q: "Okay, so would you say that once you started with the program that your confidence changed?" A: "Yeah, definitely."	4
Stu-M-7-17	A: "I think I did pretty good in there." Q: "And in terms of confidence level, you felt like there wasn't anything that you couldn't do given the environment and the tools available?" A: "If I wanted to do it, I could absolutely do it."	4
Stu-F-9-18	Q: "Okay, so if I'm understanding this right, your experience in the AREA154 program and because of some of the hands-on things, you felt like you had a better grasp of what was going on in that class or in that system than you have in the past?" A: "I would say that. Yeah. I feel I learned a lot."	4
Stu-M-8-19	"I don't know. You know I just sort of gave up at the end. Was like, I can't catch up now. I guess it was what it was."	3
Total responses 18/19	Total Magnitude for the category: **ATV Self-evaluated confidence change post AREA154 (Self-con-post)** Total ATV = (80/18)	**4.4**

Note: Student Stu-F-6-5 did not have interview data that addressed this topic. Either the question was not asked, or the data were not found.

ATV: Contrast from Freshman Biology and Post-AREA 154 confidence levels.

Interview data compiled through from the participants about their pre-AREA154 post and AREA154 confidence (expectancy) levels demonstrates that the participants' perception of their growth as a group was substantial. The students who expressed a higher level of confidence grown also noted a similar lack of confidence even a lack of memory from their biology experience. One participant stated that she had trouble even recalling what science class she had freshman year (Stu-F-18). The reasons for the their lack of confidence or expectancy were unknown. No follow-up questions were asked on this topic. Hypothetically, it could have been that they only viewed themselves as having previously lacked confidence in contrast to the robust level of confidence they felt after experiencing a full AREA154 curriculum. Given the high Affect Theme Values, it could be that had these same subjects been asked about their confidence at the end of freshman year, they may have replied differently. The samples from the subjects' interview data (Table 30) appear to validate the data presented earlier in phases I, II, and III. In other words, when we broke down the individual elements of the uLearning system the presented CBEs individually (Phases I-III) and when subjects evaluated their CBEs when evaluating the experience as a whole. The Affect Theme Value for the theme pre-program was 4.2 (indicating that subjects felt far more confident in AREA154 than in their freshman STEM class), and the Affect Theme Value for the program theme was 4.4 (indicating an increase in CBEs at the end of the 2020 school year).

Revision and visualization

All four phases were rigorously analyzed to validate cultural assumptions and generate a clear understanding of the subjects who participated in the research. Phases I and II analyzed the technology's structural features and the influence of the uLearning design philosophy. Moreover, subjects' perceptions of noncategorical data provided data on external influencing factors that could enhance or derail educational efforts. The four reflective phases served as a categorical cross-check to validate findings discovered by coding and theming subjects' recalled experiences. Finally, subjects' self-assessments about their lived experiences were coded and compiled. The findings presented information regarding the impact that AREA154 had made on their CBEs. 17 represents the most current version of the grounded theory flow chart visualization, explaining the effects on multi-active students.

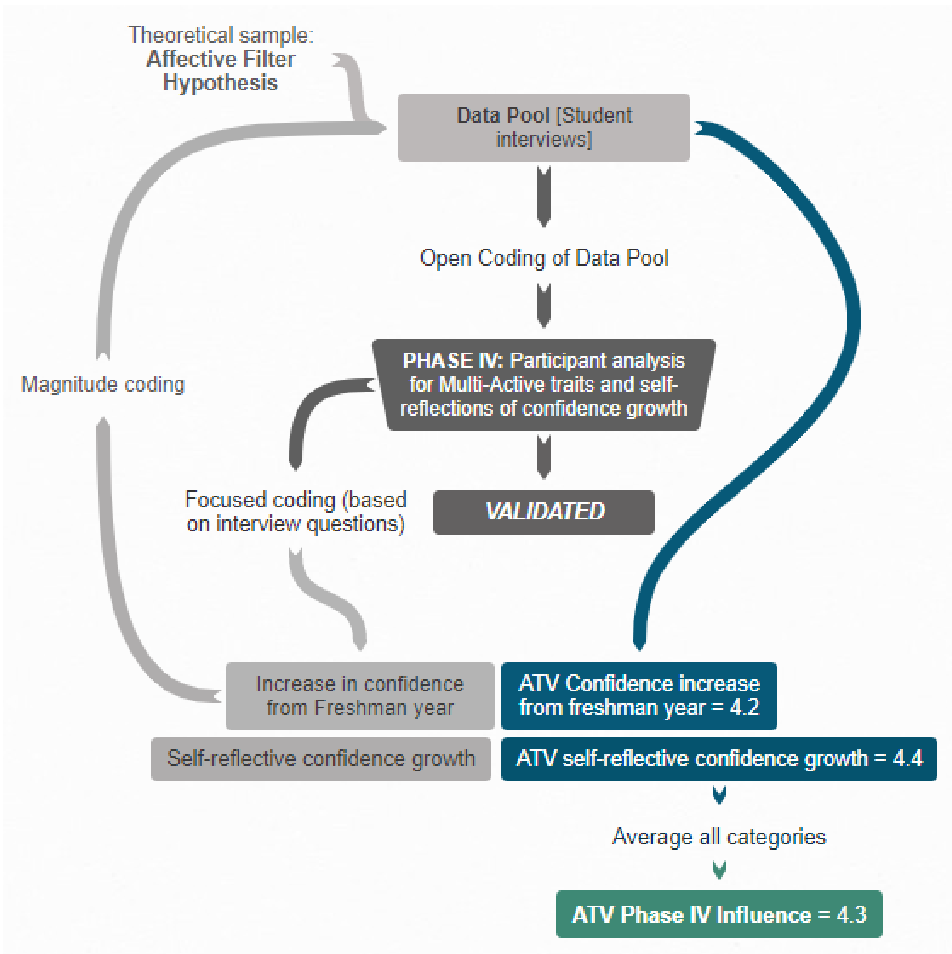


Figure 17 The visualization of Phase IV Affective Theme Values

Note: The diagram illustrates the data analysis process from the open coding of the data into major organizational phases, from that phase to the focused coding into categories that reflect the questions asked to the students. Once formed the categories were magnitude coded based on the various responses provided by the participants reflecting their various responses to that category. A numeric theme value was provided to each category once all of the participants responses were summed and averaged. An overall phase ATV is the result of the summation and averaging of the individual category ATVs.

Perceptions of success and confidence vs. academic improvement

Phase IV focuses specifically on the subjects' officially recorded achievement areas using the Aeries student data-managing software. This part of Phase IV provided findings pointing to notable increases in confidence, self-efficacy, and achievement. This information helps fortify the notion that the subjects' experiences produced a positive change in measurable factors beyond the researcher's perception.

Table 31 Coding for confidence and achievement changes, perceived and actual

Subject (Ranked by averaged course grade)	Interview Response	ATV	Top Grade (Spring 2020)	AREA154 > Bio* (Average year-long grade)
Stu-F-6-1	"I was confident with the subject, I wasn't so much with myself."	3	Tied for top	Higher
Stu-F-7-2	"Honestly, I was less confident at the start [of AREA154]. It's not normal. It took a while to get used to."	2	Tied for top	Same as
Stu-M-4-3	"It would be fair to say that I did the work because I had to. It didn't really jump out at me, certainly not inspired by it. Huge difference between the two [bio and AREA154]."	5	Top grade	Higher
Stu-F-8-4	"I wasn't confident in science [last year], I didn't really like it. Chemistry (AREA154) year was better for me." [*Response to follow-up question via text message.*]	4	Tied for top (A-)	Same as
Stu-F-6-5	*No recorded response from subject.*	N/A	N/A	N/A
Stu-F-7-6	"These are the first semester and then I just got hung up on that and it's just distracting me from the actual rest of the class. I think this is hard to do and I forget sometimes and I'm like, how do I do this now? And I definitely did struggle for sure last year."	5	Top grade (A)	Higher
Stu-F-9-7	"I basically knew nothing. It was a system, you just regurgitate the information. Not really doing your own research, just doing	5	Tied for top (A-)	Higher

	what you're told. I needed more. AREA154 was more, it was like being the researcher!"			
Stu-M-9-8	"I wasn't really that good at it, like, it was hard for me to understand. Not that year [enrollment year], that was easy." [*Response to follow-up question via email.*]	4	Second-top (A-)	Higher
Stu-M7-9	"I did pretty well in biology. I wasn't all that interested in it though. But not, like, not confident I couldn't do well. Because I was into the class I felt much more confident." [*Response to follow-up question via email.*]	5	Top grade (B+)	Higher
Stu-F-7-10	"I liked my teacher, but honestly, I had no idea what I was doing in biology. I felt I was never really good at science. That changed the next year."	4	Tied for top (A-)	Higher
Stu-F-8-11	"Biomed was career-oriented; it had a purpose. It wasn't like a normal biology class. I was worried about chemistry. People said it was hard and it was going to be different from biomed. Coming into chemistry, my confidence was shaky."	4	No	Higher
Stu-F-8-12	"I don't remember biology or any of my middle school science classes. Those classes were difficult compared to AREA154 stuff."	4	Top grade (A-)	Higher
Stu-F-7-13	"It [previous experiences] were nothing like this [uLearning]. Was never much of a science person."	4	No (C)	Lower
Stu-M-7-14	"I got taking science when I was seventh grade but never started taking it seriously until sophomore year."	4	Top grade (A-)	Higher
Stu-M-9-15	"I had no confidence in school at all. Especially science. This class was the first science-like class I've ever passed, I think, I'm pretty sure."	5	Top grade (C)	Higher
Stu-M-8-16	"I was okay at science; I liked it. Not into books or notes, or you know, the same stuff	4	Second-top (D-)	Lower

	over and over. One of the best thing about [AREA154] was it was so different."			
Stu-M-7-17	"I was bad at math, science, things like that. Teachers didn't know how to teach us the right way. Straight out of the book, just read out of the book. Kills my drive, kills my grade."	4	Top grade (B)	Higher
Stu-F-9-18	I wasn't so confident."	4	Top grade (C)	Higher
Stu-M-8-19	"I didn't care about school so much. I've never been good at it or really interested in science much. This class [AREA154] was cooler than the last. I could do it, just didn't, you know?"	4	(F)	Lower
Total responses 18/19	Total Magnitude for the category: **ATV Confidence increase from freshman year (Con-I-Fresh)** Total ATV = (76/18)	**4.2**	8/18 = Top grade 5/18 = Tied w/top 5/18 = Second-top	13/18 = Higher 3/18 = Same as 2/18 = Lower

**BIO – refers to the subjects' freshman year biology or biomedical class.*

Note: Student Stu-F-6-5 did not have interview data that addressed this topic. Either the question was not asked, or the data were not found.

The Aeries student grading system provided a graded history tracking the subject's progress throughout the academic year and with additional access to freshman STEM grades. Grade comparisons indicated thirteen of the eighteen (one of the subject's data was not accessible) subjects received higher grades in AREA154 than their freshman STEM class. Overall grade comparisons demonstrated seventeen of the subjects' AREA154 STEM grade was in the top two of the four core subjects. For thirteen of the subjects, AREA154 STEM grade was the highest or tied for the highest of the core subjects. The numbers here tend to point towards an increase in STEM self-efficacy through the CBEs in AREA154. Furthermore, fifteen of the students presented an even greater command over the content posting grades higher than Fall semester—findings from the subjects' grade comparison analysis.

Subject grades compared to other core classes:
(Code = Top-grade)

- Subjects who's highest grade was in STEM: 8 of 19
- Subjects who's STEM grade was tied with another: 5 of 19
- Subjects who's second highest grade was in STEM: 5 of 19
- Subjects who's STEM grade was lowest among core classes: 1 of 19

Subject grades in AREA154 (soph. year) vs. freshman biology
(Code = Better-than-frosh)

- Subjects who's AREA154 grade was higher than freshman Bio: 13 of 19
- Subjects who's AREA154 grade was the same as freshman Bio: 3 of 19
- Subjects who's AREA154 grade was lower than freshman Bio: 2 of 19

Subjects who's grade improved in the second semester

- Subjects who's AREA154 grade was higher second semester: 15 of 19
  (code= 2ndSem>1stSem)
- Subjects who's spring grade improved by over 10%: 6 of 19
  (code = 2ndSemResurgence)

THEORY FORMATION AND EXTRACTION

The original observable phenomena: Hispanic students struggle, quit, or fail out of high school and most notably STEM-related classes at a rate far exceeding any other minority group in the United States. Prior to the development of the *AREA154: Apocalypse Division*, the failure rate at San Jacinto High School (in chemistry) was around 40%. After two years of program implementation, the AREA154 program dropped that chemistry failure rate to under 10%. The reduction was very likely to do the program and not to any other influential source. The school nor the science department exerted any additional efforts to reduce failure rates outside of traditional means. In the process of formulating some sort of theory that might explain the observed change in achievement, a potential theory must be able identify, explain and predict various conditions related to the theorized subject. The first point of discussion challenges the findings to demonstrate the ability for all students to achieve and be able to supply an explanation if there is no observed change in achievement.

<u>Point of discussion:</u> Do students at various achievement levels demonstrate the ability to experience confidence building events, and these events provide evidence of improved STEM area self-confidence? Can the theory explain and predict situations where confidence building is and is not experienced?

Subject student achievement records indicated that subjects involved in the study represented all levels of achievement. However, it should be noted that the number of A/B students was slightly higher than those from the C/D/F ranges. Regardless, every student from every level experienced CBEs during the year. What should also be noted was the consistency with which C/D/F students experienced external struggles (from Phase III) as well as experienced technological issues (Phase I). For example, subject profile Stu-M-8-19, whose AREA154 grade was the lowest among core subjects, failed all of his spring semester classes. He was one of the three subjects that rated highest for potential domestic struggles, as it turned out. (*Code = Trouble@home*).

Not all phases of the analysis indicated an equitable impact on the students' experiences. Phase I interface data indicated that student experiences were enhanced with the site interface design while decreased in areas that included the subjects' access to a stable WiFi signal. Phase II data regarding the uLearning system provided a categorical analysis of the different factors that affected the subjects' experiences. Generally speaking, the uLearning criteria that enabled flexibility enhanced the subjects' CBEs. The ability to retake formative assessments and flexible deadline schedules was coded with a high ATV. Additional categories revealed to hamper student confidence were discovered in Phase III. Negative feedback from family members, external struggles, and the given instructor of the AREA154 program all ranked as potentially creating CREs. However, the primary focus of the study was to investigate the effect of the uLearning framework's influence on the students experience. The next discussion makes this point.

Point of discussion: Did the AREA154: Apocalypse Division program have identifiable elements of uLearning included and demonstrated that these criteria were contributors to student confidence building experiences?

uLearning provides a number of various components within the system that interface with Hispanic students' cultural behavior styles. The multi-faceted ideology was the developmental axis for building the *AREA154: Apocalypse division*. Subjects' collectively provided an overall Affect Theme Value of 4.0. It had the highest Affect

Theme Value of the first three coding phases, possibly confirming the assertion that uLearning was solvent with the Multi-Active students. While other cultural populations may benefit from uLearning, perhaps even produce similar Affect Theme Values.

Categorical data shows areas with the highest impact included fast-feedback on SRTs and other assessments, 4.7. The apocalyptic theme encases the room, the website, the examulations, and the ATN 4.5 here highly valued. The on-demand features built into the downloadable PDF (Director icon and Media icons) supplying instruction and directions for the content forgotten or missed 4.4. It was valued the same as the centralization course content on a centralized server hub for all the educational experiences 4.4. The Affect Theme Value of 4.4 for central site is much higher than the evaluation given to the site organization and content accessibility values. This could indicate that if the site had a more student-solvent design or was possibly designed as a site-app combination, the Phase I value could rise further.

The real-world application of the class information collected an Affect Theme Value of 3.9, self-pacing and flexible deadlines 3.8, the gamification of learning including the Top Agent Leader board and use of achievement points for ranking was 3.7, Social connections provided by the daily site posts and class interactivity also received a value of 3.7. The relatively high impact of self-pacing and flexible deadlines may be more than just for indulging procrastination. Lewis explained that Multi-Active cultures inherently do not view deadlines as a top priority. Important, yes, but not the same level of importance as those who were Linear-Active.

Interestingly, the idea that a student could use nearly any internet-connected device anywhere on the planet to interact with the program only provided a very mild

CBE Affect Theme Value. However, this finding makes more sense when considering the student Multi-Active profiles and backend showing low after-hours engagement numbers.

Phase III recognizes the external factors that can affect a student's education, and no system stands in a vacuum. Outside forces influence the individual while engaged in any type of learning. Therefore, to adequately address Phase II's overall impact, Phase III considerations must be made and consolidated into the theory to more accurately predict students' overall uLearning experiences.

Areas of higher impact included the subjects' inherent interest in science 4.0. This category reflects the subjects' view on science after their AREA154 experience and, therefore, could be skewed, not truly representative of their inherent interest in science. The personal motivations for learning had a wide range of codes ranging from the entertainment value of the AREA154 theme to just being interested in the grade. Motivations varied greatly. Those who indicated an intrinsic motivational theme collectively created an Affect Theme Value of positive CBE value of 3.9 while enrolled.

The finding for family interactions could be considered a bit misleading. The Affect Theme Value of 3.0 indicates that it did not influence in either direction. Knowing that Multi-Active cultures put family as a very high priority, this information does not appear congruent with the Multi-Active profile. The finding began to make more sense when the sources of the value were considered. Subject data indicated that the students either had relatively positive CBE interactions with family, which included frequent conversations about class, supporting study time and the like.

Unfortunately, not everyone's experiences were as supportive. Some of the students insinuated that there were "troubles at home" but never went into details. The one very evident commonality was the connection between students with trouble at home and the CRE impact on the subjects' school experiences. Every subject coded this way was either at the bottom of the achievement list of operations far below their academic potential.

Intense emotional drama and cognitively derailing events are not limited to the home. For example, Stu-7-17, remarked how his "crazy girlfriend" in the spring represented a very large CRE. The social distraction caused a two-letter grade drop in his STEM grade. Only through some heavy mentoring did the subject even pass the class—events similar to this happen infrequently but devastating when they do. Three of the subjects experienced some form of "trouble" that was out of anyone's ability to control yet hugely impacted their academic performance. The collective Affect Theme Value for external struggles was 2.8. One could argue that a different set of students may not have warranted the same collective score resulting in a higher Phase III average.

Conversely, the opposite argument could be made. This section attempted to get a "flavor" of the impact. Larger sample studies involving non-categorical traumas would need to be done to assess if the external struggle's theme was represented with greater real-world accuracy.

The final category analyzed was the impact having a different instructor might have on the subjects' experience. Note the Affect Theme Value has a low value of 2.5. The low value is not to say that the teacher detracted from the experiences, quite the opposite. According to subject interview data, the course could very likely not be taught well by anyone else, not tallied officially; a rough estimate would put the CRE values for this down around 1.2. Many subjects repeated the notion that the person who created the curriculum would be the best at teaching it. The subjects' consensus pointed to the possibility that AREA154 was, as one subject stated, a “one pony show.” After discussions with the participants about teachers’ personality traits, instructional habits, personalities, some agreed that similar ends could be attained with training and the right sort of teacher.

These findings tend to point to an inherent weakness in the implementation of AREA154 in other classrooms. One of the more revealing findings from subject interview data centered on the teacher’s willingness to invest in the theme. The subjects felt that endorsing the thematic emotionally charged elements of the program appear to be directly correlated when successful iterations of AREA154 were launched. That is not to suggest that teachers who deploy a uLearning system need to follow the curriculum narrative strictly. Quite the opposite, actually. A teacher who uses the AREA154 system as a start could branch out on their own, develop new case files, adjust the existing cases, and write their SRTs, as long as the narrative grows with it. This example might be the ideal possible outcome. AREA154 appears to be more than just a product or just a design. It is a seed. A kernel that, when planted in the right place, could grow into something spectacular. Over and over, subjects responded how the experience could not get any better because the teacher was the program creator. Statements like these (From Phase III) reinforce the notion that multi-active students applaud and endorse that sort of ownership over the curriculum. However, that begs the question. To participate in the study, the students had to state that they identified as culturally “Hispanic.” The next discussion topic raises the point about how one might go about verifying that assumption.

They might identify with Hispanic ethnicity for genetic reasons, but do they also reflect the sort of behaviors that Lewis (2010) stated Multi-Active people tend to have.

Point of discussion: Where students benefiting from the program were classified as Multi-Active through various assessment tools?

The Multi-Active confirmation came from a variety of different sources of data. Establishing the psycho-social connection to the students' self-perceptions underpinned the investigation. The data collection on multi-active behavioral confirmation took the form of a question-and-answer session during the interview. On average, the students chose Multi-Active traits 7.7 times out of ten questions. Four of the subjects rated as a nine (9), which was the highest recorded value. All but one of the students overtly described themselves Multi-Active with a minimal score of 6 of 10.

Oddly one subject, Stu-M-4-3, reported with a score of four (4) out of ten, clearly more Linear-Active than Multi-Active. The data was puzzling as the student actively described himself and his family as Hispanic, yet, he scores as Linear-Active. Two interesting observations contribute to understanding this response. During the interview, Air Force paraphernalia pictures were cluttered on a shelf with metals and photos of people in uniform. It turns out that subject Stu-M-4-3 is the product of a military family. This observation would likely describe the Linearity in his thinking and decision making. Also curious was the subject's behavior at school. Noted on many occasions (and in subject profile memos under observations) subject would engage in social conversations with fellow ROTC associates during class. When asked about their productivity, the subject would often state that he would have it done but would later. This reaction, the notion to favor emotionally gratifying or engage in feeling-based logic, is hallmark psycho-social behavior for multi-Active people. Stu-M-4-3 has done what several other high-achieving members of the study have done. According to the interview findings, this particular trait can only be accomplished by a powerful outside influence capable of overcoming their primary psycho-social tendencies.

The analysis of the AREA154 uLearning elemental pieces tended to suggest that the students felt the system had provided them with confidence building experiences. The other side of that coin posits the question about the impact the students felt the system had on them as a whole. The next area of discussion tasks the data with supplying information about the students' changes in confidence in their own words. How would they describe their experience? Was the overall experience greater than the analysis of the individual parts?

<u>Point of discussion:</u> In their own words, did uLearning participants indicate their time enrolled in the uLearning program provided confidence building experiences influencing an increased level of self-confidence in STEM subjects?

Phase IV self-assessments indicated that students' responses were coded at an average of 4.3. Subjects noted a significant change in confidence and success between their freshman and sophomore years with an Affect Theme Value of 4.2. Moreover, the average Affect Theme Value rose to 4.4 by the end of their sophomore year. As a whole, subjects saw their AREA154 STEM experience as a highly confidence building experience – *almost regardless of what their final grades were in the class.* Some of the students most inspired by their AREA154 experience were at the bottom of the achievement scale. Perhaps surprising at first, but this behavior is in line with Multi-Active people, according to Lewis. Achievement is not their highest priority. If they find interest in something, seeking out information on that topic may or may or result in a student "playing the game of school" and participating in the Linear-Active achievement measurement system (grades).

Moreover, subjects' Aeries data supported the self-assessment. Roughly 70% of the students had their highest grades in AREA154. The same percentage of subjects presented improvements in their STEM grades over their freshman year STEM course. Finally, subject profile data demonstrated 78% of students achieved an even higher grade in the second semester. Half of the subjects that improved increased an entire grade letter from the previous term.

Articulated theory - *The Apocalypse Effect*

The study's first research question (RQ1) asked about how ubiquitous learning technologies, in the form of the *AREA154: Apocalypse Division* chemistry program, impact Multi-Active students' perceptions of confidence building experiences. In short, it did, and the summarized version of the theory explains:

> **Summary:** Students that are psycho-socially disenfranchised from Linear-Active learning environments, as Multi-Active students appear to be, can have confidence building STEM experiences and measurable academic gains through the use of *key* ubiquitous-access designed learning technologies immersed in dramatic dissonance-rich narratives pragmatically connected to real-world events. Essentially, the students had to be able to coordinate learning with cultural demands, emotionally *feel* the personal impact of the curriculum, and translate that feeling into a real-world setting.

uLearning, assessed in its totality, increased subjects' confidence building experiences by providing a centralized, self-directed, need-driven distribution point in-school curriculum. uLearning systems, like *AREA154: Apocalypse Division,* provides the flexible access needed by Multi-Active students whose natural psycho-social behaviors are incongruent to the traditional Linear-Active U.S.-based school systems. Categories such as Fast-feedback (ATV=4.5), self-pacing (ATV=3.8), On-demand instruction (ATV=4.4), central site content deployment (ATV=4.2), and a dramatic real-world connected narrative (ATV=3.9) were categories identified by the subject group as having a strong influence over their self-perceived confidence enhancement. The theme codes used to reveal CBEs indicated that every one of the uLearning criteria had, at the very least, a mild overall assessed CBE. Phase I provided insight into the subjects' observations of the site interface and revealed that the most restrictive experience was due to their at-home network when attempting to access the content (ATV=2.8) when needed. The usability of the site (ATV=3.8) and the site's organization (ATV=3.5) both demonstrated moderate CBEs. Phase three represented the students' non-uLearning dependent experiences while enrolled. Overall, their experiences – including the possibility of the program's designer not being the class instructor – still appeared to be at the very least neutral (ATV=3.2). The important takeaway from Phase III points to the uLearning system being successful for most students even with an alternative qualified instructor and despite the external struggles that individual students might experience during the term.

Research question 2 (RQ2) posited a request for proof. Proof that the confidence building claims from the subjects reflected some measurable gains through an alternative means of measure. The subjects' profiles identified areas of notable improvement in achievement over their freshman year STEM class and improvement from the Fall semester to the Spring semester. The progress was not universal across all subjects, nor was the amount of gain the same for all subjects. However, when all phases of the subjects' experience with the uLearning system were combined, the overall impact indicated a marked improvement in self-confidence and a general increase in academic achievement in this STEM chemistry program. Opinions were useful, but establishing a working theory requires multiple levels of evidentiary support.

GT uses cyclical analysis to answer questions as they arise throughout the investigation. Each of these 'theory tests' resulted from questions during the study centering on testing or supporting the developing theory. The influence of these questions can be seen in Appendix H.

Suggestions for Theory Application and Expansion

Application for Hispanic STEM education

The question of, "Can Hispanic students have confidence building experiences in an environment that is psycho-socially not built for them?" now has data to form a theoretical answer. The theory's current flowchart-like shape resulted from extensive multi-phased evaluations of technology, learning content, and behavioral profiling. Multi-Active students respond to an environment that allows them to feel their way through it, improvise, facilitate options and move at a pace that works for them. Lewis (2010) noted that Multi-Active people are not planners nor respond to overly stringent unforgiving deadlines. This study found, very clearly, that every subject wanted to be successful and confident. Even those who were not "successful" displayed lament wished they could have been. AREA154, as a program guided and designed by uLearning principles, produced an overall Affect Theme Value of 3.53. This value included the negative variables of life experiences and attempted to negate the influence of a highly trained national-award willing instructor. Remove those, and the Affect Theme Value jumps to 3.8, a more impressive number but not realistic. The evolving theory provides a map to place programs against and identify areas of improvement. AREA154 has areas to improve, for sure, and lacking this theory making high-impact improvements is reduced sophisticated guessing and checking.

This study shows Lewis's findings regarding culture to be an accurate identifier, explainer, and predictor of Hispanic cultural fluences on behavior. The findings become a guiding instructional paradigm for schools with high numbers of Hispanic Students. Additionally, schools of teacher education in regions with a large enrollment of Hispanic students would likely benefit from observing the stark psycho-social differences between U.S. Schools and Hispanic students and families.

However, further research in this area would be advised. Lewis' trope on cultural behaviors was designed originally for business applications. This study found that the model also applied to high school students, but more examples in education would likely enhance the credibility of Lewis's assertions applied to education.

Application for students with low affluence

The subject pool of students all reside and attend school in San Jacinto, CA. This is not an affluent town. According to the 2016 Riverside County demographics report, San Jacinto lists the 3rd lowest per capita income of all 21 cities in Riverside County over the population of 35,000. Lewis (2010) presented a list of psycho-social behaviors associated with Hispanic people. As it turns out, the same sorts of psycho-social behaviors are attributed to people who occupy the lower strata of the income ladder. The scope of socio-economically disadvantaged students was beyond the scope of this study. However, additional research including both Hispanic and low-income groups may provide insight into additional theory application areas. Perhaps, a study with a variety of low-income “white” students or African American students would provide more inclusive data and potential opportunities to ascribe Lewis’ Multi-Active behaviors with low-income students. The findings could provide a broader range of students that the AREA154 uLearning program or programs designed like it could be of great benefit.

<u>Application for educators’ professional growth</u>

As mentioned earlier, the AREA154 uLearning design has already undergone some level of transformation to other platforms. The area of learning in virtual reality is notably limited. After a thorough scanning of applications available on the Oculus and Vive stores, very little exists in the content development area the ARK Agent project seeks to address. Perhaps that market segment is not profitable, or there is a need, and the skill sets required to produce such a VR app are so rare the segment remains unfilled simply by a lack of qualified people to build the software. In any case, the research opportunities to investigate STEM learning in virtual reality are immense and continue to develop.

One can make the argument that there is a one-dollar and a ten-dollar way to do anything. The technical skill involved in making AREA154: Apocalypse Division is diverse and likely not something that can be replicated in an afternoon Zoom call. That being said, there are more ways to utilize the uLearning axial paradigm, but with technology, that is far less complicated. Investigations into simplified versions of uLearning systems could mark an important starting point for teachers. Research opportunities exist for investigating less complicated means of uLearning deployment and researching how uLearning environments could impact younger students in middle school or possibly as far down as upper elementary grades.

Schools of education could benefit from the development of uLearning courses where multiple classes (much like the Eduneering Initiative) could be strung together to help instructors learn a technologically advanced instructional paradigm. Careful structuring of classes could most likely result in the students building the beginnings of a customized program. Boise State University has several programs that produce degrees and certificates that ensure a certain level of technical knowledge. However, that knowledge represents a smattering of a variety of technologies. Useful, but lacking the focus of something like an "Eduneering Initiative." Within such a program teacher walks away with a certificate of compliance *and* a site of their very own where they can design, sculpt, and build learning material that enhances their passions and engages whatever challenging clientele they may encounter. Professional development on that scale could be game-changing, not only for Multi-Active students but any other type of student that might benefit from the "Apocalypse Effect."

CONCLUSION

uLearning technological designs date back almost 30 years. The idea is not new. Nor is the technology used to conceive, design, build, and deploy the AREA154 uLearning experience. All of the tools and programs are relatively commonplace. WordPress is not new, Sensei LMS was published in 2009, and the Adobe media software updates versions of software that first came out fifteen to twenty years ago. However, the design is novel. The lens by which the technology, the instructor, and the curriculum work together: That was new.

Theoretical contributions of the study

The study findings indicate several interesting potential applications for the theory, whether or not it is expressed in the form of the AREA154 iteration used in this study. The multi-phasic and categorical breakdown promoted the use of magnitude coding that, based on subject interview responses and site statistics, could provide a value that could give magnitude-themed feedback for this study and predict the overall impact of potential categorical changes. For example, a STEM instructor uses the theory to design a website for earth and space science. The categorization process in this study was a segregated set of criteria through which the teacher could either ask himself or a group of students to react regarding their CBEs. The teacher may use questions of their own design, but the evaluation model is in place. The STEM teacher could develop a few questions for each category discovered in PHASES I-III and put them in a Google form or something similar. The findings could represent an initial step towards identifying problem areas, assuming the teacher does not already know the problem's location. Experienced instructors tend to know.

Moreover, areas of improvement could also be identified through a similar means of analysis. In this study, data for the categories of organization and usability could be enhanced with a better interface and more intuitive site organization. By focusing improvement efforts on just these two components by 0.5, each increases the overall ATV value to 3.63, a small, focused change that ultimately impacted every student's experiences in the program. Using a categorized flowchart (like the ones used in Figure 2 from the Chen and Lin study (2014), the theory could provide an uncommon level of control when measuring changes within a uLearning system.

Also uncommon was the remarkable and varied training the system designer underwent to both conceptualize the environment and attain the technical capacity to materialize the idea. An unexpected, though not surprising, theoretical contribution to education would be the training associated with building such systems. The training discussed in Phase III addresses a crucial point. The overall Affect Theme Value for the AREA154 experience could have been higher if the technical training was available. The subjects in the study respectfully noted the relative lack of creative technical skill in most teachers. They were aware of the possibility of someone possessing the skill-sets for evolving and maintaining a uLearning system were rare, not impossible to attain, but unlikely the average teacher would have them. The theory implies that better technical training on the technical subjects connected to uLearning systems would have a notable effect on ATVs for Phase III, thus enhancing the overall experience.

The staff training trends in the San Jacinto Unified School district (Pre-COVID) centered around Google Suite, Pre-built corporate LMS sites like PowerSchool, Haiku, and gadget sites like Kahoot, independently they would not be considered as uLearning technologies. Communication with teachers in surrounding districts is infrequent, but recent communications indicate educational technology exposure is limited. Granted, Google Suite offers a wide range of simple and highly integrated media production tools; it could be a good jumping-off point. However, these suites lack the creative power to produce anything as interactive or immersive as AREA154.

As previously noted, this study points out the importance of the unification of design, instructor, and technology. This realization was product-independent. One does not need to use the same toolset to accomplish similar, not exactly, but workable facsimiles of uLearning environments. The study emphasized the need for an entire systemic phase shift in teacher technology training.

Anecdotal observations suggest that districts' edtech training panders to teachers pleading for them to try, possibly invest, into anything that leads to better classroom results. Typically, in these training sessions, little is learned, and less is applied. The day of training ends, and things go on as they were. Consider the implications of the findings in this study. A research-backed solution that can and has made a notable difference. A more effective approach might offer the best teachers everything, rather than providing something for everyone. In other words, offer hungry, motivated teachers rigorous high-end training on-site generation, Adobe production software, and SQL databases. Then provide a venue to openly create a new iteration of their curriculum with uLearning as the axial design guide. Follow their progress publicly, open it to others to watch and follow as well. Upon completion, celebrate those teachers like rock stars. Their success seeds the motivation that pulls others into the program. New participants selectively choose to maintain the training rigor and manage the quality of the output.

The study's scope does not include topics like edtech training nor the distinct methodology by which the program was built. If success was found in the product, so was it also in the means that delivered it. The implication of expanded teacher training may, theoretically, be one of the most important implications of the study. The skills used in this study have already created the beginnings of a spin-off edtech training program called the “Eduneering Initiative,” where teachers would be trained on the creative, psychological, and technical skills used to construct AREA154.

Hispanic students have been failing STEM subjects and dropping out of high school at a rather phenomenal pace, and it does not appear to be slowing down. This study developed a theory, a blueprint, that demonstrates a way to improve the situation. The theory is complicated with many technical moving parts. The elements of the theory are not traditional. They tend not to follow a five-step lesson plan. There’s no traditional homework cycle, nor does it depend on the typical instructional resources. Implementing any high school STEM program would require change, but perhaps AREA154 may require established teachers to change too much. This study developed a uLearning theory that delineated skills requiring teachers to embrace additional or drastically different professional philosophies that might conflict heavily with their traditional Linear-Active training and teaching experiences. More optimistically, the AREA154 program has the best chance of thriving if planted in a STEM classroom where the teacher is either new to the teaching field, new to the subject matter, or perhaps an instructional experimentalist. Decades of anecdotal evidence suggest that teachers who were firmly established in their practice, unless provided a powerful stimulus to change, would not willfully adapt unfamiliar instructional methods. In any case, the theory was clear on the instructor's importance for the program's success. Like planting a tropical bush in the desert, if AREA154 is not seeded in the right environment, it will die and possibly cause confusion, increase confidence-restricting experiences, and push students further away from STEM areas rather than pull them into it.

Reflections as primary researcher / designer / instructor

A new type of student meant a unique flavor of problem. These students made confounding choices, and the first few months offered time to seek solutions though none came quickly. In the fall semester of the Boise State University Doctoral program, in a class called "Culture and technology," the Lewis Cultural Triangle sparked insight into an answer. The ignition point led to retooling and rebuilding the old curriculum into the *AREA154: Apocalypse Division*. During the first two years of its implementation, both contents from the doctoral program (focusing on Multi-Active psycho-social tendencies) and students' (users) experience-based feedback (conversations, observations of student-site interactions), the system was built, torn down, rebuilt, in a constant cycle of observing, formulating solutions, deploying solutions, and analyzing feedback. The process was very much like the cyclical GT approach taken when the research is unfamiliar with the area of study.

The district cabinet visited the room four times during that time period. According to former principal Luke Smith, that frequency of visitation was highly irregular, yet begged some impressive esteem. Three different SJHS administrators commented during teacher evaluation debriefings on the high concentration of students actively engaged. It was assumed that other classes performed differently based on the reaction of those who had been in other chemistry classes. Allegedly, it was a rare sight to witness.

Transparency of analysis is one of the more essential merits of a qualitative study. It should allow a reader to see the experiences, biases, and previous experiences that lead up to the completed research. Transparency provides the means for the reader to see the evidence and derive a conclusion for themselves, much like a juror in a court case. The researcher for this study was no stranger project involvement, much of which demands direct involvement. One of the most important lessons learned while building and implementing educational technology platforms involves learning how to remove oneself from the development equation. If the product is going to get better, it needs to be critically evaluated. For the product to work, the evaluations must be the truth, regardless of one's personal feelings about the matter.

As an illustration of the effect of self-removal, take a video of someone, anyone. When shown back to them, one may demonstrate some emotional reaction reflecting a narcissistic as the image reflects incongruently with one's elevated self-image. Perhaps the response feigns some shock at how "bad" one may look or sound. People have a sensitivity about how they appear to others. This emotional reaction applies to video, audio, one's writing, painting, or anything else that reflects a sense of identity. Bias stems from this notion and can skew data aligning results with one's identity reinforcing a previously held self-image. For this reason, all industry-sponsored research tends to be more heavily scrutinized. Any investigation for the truth that closely incorporates the researcher, the subjects, and the study should face higher scrutiny.

The question of how one separates work from personal emotions takes work and practice. The lead researcher in this study has participated in many multi-year self-driving projects that have succeeded and failed. Failure is a hard lesson to learn, though it tends to be the most meaningful. Many early projects failed due to the designers' resistance to outside criticism and, despite the truth being share, shrugged it off to build something that endorsed self-recognition rather than self-gratification for designing a working product. Letting go of 'self' became part of the failure lessons that lead to the development of other successful large projects.

Distinct advantages arise when one is the site administrator, curriculum designer, and instructor. If something goes wrong, or some part of the site or downloadable PDF does not function as it should, the fix can be implemented almost immediately. For example, this happened on many occasions. The first-period class demonstrates a need for an additional feature on the PDF. In recognition that the new feature's addition could improve the students' experience, that feature could be added to the PDF in Adobe InDesign, saved to the PDF, and then uploaded to the media cache online. Before the second period starts, that new feature is already loaded and ready. Specifically noted by Stu-F-9-7, she indicated that calculator links were added to the PDF and felt the additional steps saved by opening a calculator in a new tab were far better than trying to find one on her phone.

She did not realize that the calculator link was added two periods prior because the first period appeared to need one, and not having one caused many students to stop working. Moreover, the calculator used on the PDF training was the same calculator used on the district math assessments providing practice and familiarity. This story tells how instructional technology and curricular cross-training can serve the students' needs when they need them served while emphasizing future staff technology integration training options.

Adaptation and possible implementation

A possible expansion for AREA154 was deployed in a private school run by Randall Gwin. As in the previous examples, Mr. Gwin had to take on teaching a STEM chemistry course. Not being a chemistry specialist or even a science major, the AREA154 system provided a pre-built, semi-proven platform that could function as a starting point. Mr. Gwin, a doctoral student at Boise State University and a cohort member of the program designer, was familiar with the AREA154 concept. It came up and has been discussed several times in a variety of classes. The students' pictures, who by profile appeared to be very bright and highly self-motivated, blazed through the curriculum. Pictures of their labs, comments about the curriculum were sent back occasionally to share their experiences. Reactions among the students and parents were positive, and the curriculum as delivered by Mr. Gwin was well received. Mr. Gwin also went so far as to arrange an "Ask the Director" day where the students who finished the program could ask the Director, the program designer, any question they wanted. This conversation took place 14 time zones apart but was the highlight of the experience, according to Gwin. The program was implemented the following year but with a different teacher. Feedback on the new year has been limited.

As of February 2021, conversations between Noel Quinones creator of *Operacion Exito* (operacionexcito.com) are leading to developing a hybrid version of the uLearning system. Rather than case files that last for months, small pocket-sized missions would be the focus. Completing the mission packets raises the “Agent’s” Status among the group of individuals enrolled in the program. In essence, they are operating like the gamified curriculum in the AREA154 uLearning system. *Operacion Exito* currently has 50,000+ plus participants across 5 South American countries and is based in Puerto Rico. Mr. Quinones was referred by someone who had attended a presentation covering the preliminary research on the *AREA154: Apocalypse Division* uLearning design concept and its impact on Hispanic youth.

VROsmosis

Christophe Gomez, a former video game producer and now head of the Video Game Design College at The Art Center, caught wind of the AREA154 concept through a conversation at the SIGGRAPH conference where he met with the designer, instruction, and educational researcher behind AREA154. After several lengthy discussions about virtual reality and its potential for next-level science instruction, a team of four highly trained professionals formed VROsmosis. Over the year, a VR experience directly influenced uLearning principles, and inspired by the *AREA154: Apocalypse Division* theme, a demo was produced. The working title of the project is called *ARK Agent: Project Apollo*. The term “ARK Agent” is directly based on students' role while enrolled in the *AREA154: Apocalypse Division* classroom experience. The current Apollo Project narrative was based on the “Zombie” Case file found in the AREA154 curriculum. Development is in its beginning stages. Further development will likely build from this research and offer additional opportunities to research the CBEs provided through the virtual reality interface.

Application to other high school subjects

According to the designer of AREA154, math would be the Holy Grail, so to speak, for program implementations. Initial efforts to begin talks on creating a math-oriented AREA154 stalled as the Math department demonstrated resistance to the idea of a thematically directed math class. The idea was foreign to them, and the idea of becoming thematically involved in the class themselves was even more foreign and less likely to happen.

Another attempted to broaden the uLearning ideology was made with the Language department. The department head was all for the concept and felt that the narrative would fit well within the class. Additionally, the idea of having the uLearning systems in place would sell well to the rest of the department. However, talks stalled when talking about the skills needed to make the system function properly was introduced. One could posit that the department is not very tech-savvy and was off-put by the type of technology required to build the system and sustain it.

Limitations to the study

The pandemic and the havoc brought upon the public schools stands as the single most limiting feature to the study. The changes in protocols and students' absence from the campus drastically changed the original data collection methods for this investigation. When the original proposal was presented, there was a potential that schools would come back to the site in at least some form in the Fall. Unfortunately, that was not what ultimately panned out. As a result, several complications arose that may have impeded the study.

Had students been at school, reaching potential subjects would have been far less labor-intensive. Due to pandemic protocols, access to former students became almost entirely dependent on email. This fact may have a built-in bias that explains why more students at the lower end of the achievement scale didn’t reply to be interviewed. While seeking subjects, a group of students was selected based on the Methods section's criteria on participant selection. The COVID-19 conditions added to the complexity of acquiring subjects and ensuring an appropriate distribution of students across the achievement spectrum.

REFERENCES

2019-20 Enrollment by Ethnicity. (n.d.). https://dq.cde.ca.gov/dataquest/dqcensus/enrethlevels.aspx?agglevel=School&year=2019-20&cds=33752003330529

A nation at risk. (1983). http://www2.ed.gov/pubs/NatAtRisk/risk.html

Alfaro, E. C., & Umaña-Taylor, A. J. (2015). The longitudinal relation between academic support and Latino adolescents' academic motivation. Hispanic Journal of Behavioral Sciences, 37, 319–41.

Alfaro, E. C., Umaña-Taylor, A. J. and Bámaca, M. Y. (2006). The influence of academic support on Latino adolescents' academic motivation. Family Relations, 55, 279–91. https://doi.org/10.1111/j.1741-3729.2006.00402.x

Altshuler, S. J., & Schmautz, T. (2006). No Hispanic student left behind: The consequences of "high stakes" testing. Children & Schools, 28(1), 5-14.

Baker, C., Wuest, J., & Stern, P. N. (1992). Method slurring: The grounded theory/phenomenology example. Journal of Advanced Nursing, 17(11), 1355–60.

Bandura, A. (1977). Social learning theory. Prentice-Hall.

Barbosa, J. L. V., Hahn, R. M., Barbosa, D. N. F., & Saccol, A. I. D. C. Z. (2011). A ubiquitous learning model focused on learner interaction. International Journal of Learning Technology, 6(1), 62–83.

Behind, N. C. L. (2002). No child left behind act. Washington, DC: US Department of Education.

Borjas, G. J., & Katz, L. F. (2007, May). The evolution of the Mexican-born workforce in the United States. In Mexican immigration to the United States (pp. 13-56). University of Chicago Press.

Boutakidis, I. P., Rodríguez, J. L., Miller, K. K., & Barnett, M. (2014). Academic engagement and achievement among Latina/o and non-Latina/o adolescents. Journal of Latinos and Education, 13(1), 4-13.

Boyle, G. J. (1983). Effects on academic learning of manipulating emotional states and motivational dynamics. British Journal of Educational Psychology, 53(3), 347–57. https://doi.org/10.1111/j.2044-8279.1983.tb02567.x

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. Educational researcher, 18(1), 32-42.

Campbell, A. T., Eisenman, S. B., Lane, N. D., Miluzzo, E., Peterson, R. A., Lu, H., . . . & Ahn, G. S. (2008). The rise of people-centric sensing. IEEE Internet Computing, 12(4), 12–21.

Carr Jr, J. E. (2013). What is the impact of full access to technology on the achievement of the Hispanic student? ProQuest LLC.

Catherall, P. (2017). Student perceptions on skills and learning challenges in the use of educational technology in a low-contact, blended and professional learning context: a grounded theory of 'improvised learning' (Doctoral dissertation, Manchester Metropolitan University).

Chamberlain-Salaun, J., Mills, J., & Usher, K. (2013). Linking symbolic interactionism and grounded theory methods in a research design: From Corbin and Strauss' assumptions to action. Sage Open, 3(3), 2158244013505757.

Chang, A., & Chang, M. (2006). A treasure hunting learning model for students studying history and culture in the field with cellphone. In Proceedings of the 6th IEEE International Conference on Advanced Learning Technologies (ICALT 2006), July 5–7, 2006, Kerkrade, The Netherlands (pp. 106–108).

Charmaz, K. (2006). Constructing grounded theory: A practical guide through qualitative analysis. sage.

Charmaz, K., & Belgrave, L. (2012). Qualitative interviewing and grounded theory analysis. The SAGE handbook of interview research: The complexity of the craft, 2, 347-365.

Chen, C. C., & Lin, P. H. (2016). Development and evaluation of a context-aware ubiquitous learning environment for astronomy education. Interactive Learning Environments, 24(3), 644-661.

Chen, N.-S., Teng, D. C.-E., Lee, C.-H., & Huang, (2011). Augmenting paper-based reading activity with direct access to digital materials and scaffolded questioning. Computers & Education, 57(2), 1705–15. https://doi.org/ 10.1016/j.compedu.2011.03.013.

Chiu, P., Kuo, Y., Huang, Y., & Chen, T. (2008). A meaningful learning based u-learning evaluation model. In 2008 Eighth IEEE International Conference on Advanced Learning Technologies, Santander, Cantabria (pp. 77–81).

Christofferson, J. (2017). Understanding by Design approach to a Next Generation Science Standard in high school chemistry: Chemical reactivity.

Chu, H. C., Hwang, G. J., & Tsai, C. C. (2010). A knowledge engineering approach to developing mindtools for context-aware ubiquitous learning. Computers & Education, 54(1), 289-297.

Clapham, A. (2012). Exploring teachers' experiences of educational technology: a critical study of tools and systems (Doctoral dissertation, University of Nottingham).

Cohen, G. A. (2014). The labor theory of value and the concept of exploitation (pp. 135-157). Princeton University Press.

Collins, A. (1994). Goal-based scenarios and the problem of situated learning: A commentary on Andersen Consulting's design of goal-based scenarios. Educational Technology, 34(9), 30–32.

Cope, B., & Kalantzis, M. (Eds.). (2010). Ubiquitous learning. University of Illinois Press.

Craft, K. F. (2011). Academic performance differences among Texas grade 8 students who are

White, Hispanic, or limited English proficient. Sam Houston State University

Creswell, J. W. (2007). Qualitative inquiry and research design: Choosing among five approaches.

Creswell, J. W., & Creswell, J. D. (2017). Research design: Qualitative, quantitative, and mixed methods approaches. Sage publications.

Creswell, J. W., & Poth, C. N. (2016). Qualitative inquiry and research design: Choosing among five approaches. Sage publications.

DeNavas-Walt, C., Proctor, B. D., & Smithi, J. C. (2010). Income, poverty, and health insurance coverage in the United States: 2009 (Report No. P60-238). Government Printing Office. http://www.census.gov/newsroom/releases/archives/income_wealth/cblO-144.html#tablea

Denzin, N. K., & Lincoln, Y. S. (2005). Introduction: The discipline and practice of qualitative research.

Dey, A., Hightower, J., Lara, E., & Davies, N. (2010). Location-based services. IEEE Pervasive Computing, 9(1), 11–12. https://doi.org/ 10.1109/MPRV.2010.10

Doyle, T. (2015). 1:Web transition: One school's experience. CSLA Journal, 39(1), 20–21.

Eccles, J. (1983). Expectancies, values and academic behaviors. Achievement and achievement motives.

Eccles, J. S., & Wigfield, A. (2002). Motivational beliefs, values, and goals. Annual review of psychology, 53(1), 109-132.

Educause. http://www.educause.edu/books/educatingthenetgen/5989.

El-Bishouty, M. M., Ogata, H., Rahman, S., & Yano, Y. (2010). Social knowledge awareness map for computer-supported ubiquitous learning environment. Journal of Educational Technology & Society, 13(4), 27–37.

Embong, A. M., Noor, A. M., Hashim, H. M., Ali, R. M., & Shaari, Z. H. (2012). E-books as textbooks in the classroom. Procedia—Social and Behavioral Sciences, 47, 1802–09. https://doi.org/ 10.1016/j.sbspro.2012.06.903.

Erickson, A. (2013). Ubiquitous learning: Strategies for pedagogy, course design, and technology, edited by Terry T. Kidd and Irene Chen. Teaching Theology & Religion, 16, e10–e11. https://doi-org.libproxy.boisestate.edu/10.1111/teth.12069

Evolution of the mobile phone: From simple to smart. (n.d.). https://www.tigermobiles.com/evolution/#start

Felder, R. M., & Silverman, L. K. (1988). Learning and teaching styles in engineering education. Engineering Education, 78(7), 674–81.

Fendt, J., & Sachs, W. (2008). Grounded theory method in management research: Users' perspectives. Organizational Research Methods, 11(3), 430–55.

Gandara, P., & Contreras, F. (2009). The Latino education crisis: The consequences of failed social policies. Harvard University Press.

Garcia, E. E. (2001). Hispanic education in the United States: Raíces y alas. Rowman & Littlefield.

Gibbs, G. R. (2002). Qualitative data analysis: Explorations with NVivo. Open University.

Gillard, J. (2007). Time to end the culture war. AQ-Australian Quarterly, 79(4), 10-13.

Glaser, B. (1978). Theoretical sensitivity. Advances in the methodology of grounded theory.

Glaser, B. G. (1978). Strauss (1967): The discovery of grounded theory; Strategies for qualitative research. Wiedenfeld and Nicholson.

Glasser, B. G., & Strauss, A. L. (1967). The development of grounded theory. Chicago, IL: Alden.

Graf, S., Kinshuk, & Liu, T. C. (2009). Supporting teachers in identifying students' learning styles in learning management systems: An automatic student modelling approach. Journal of Educational Technology & Society, 12(4), 3-14.

Grbich, C. (2007). Qualitative data analysis: An introduction. Thousand Oaks, CA: Sage.

Greckhamer, T., & Koro-Ljungberg, M. (2005). The erosion of a method: Examples from grounded theory. International Journal of Qualitative Studies in Education, 18(6), 729-750.

Greenhaus, K. L. (2014). Teachers' Perceived Influences on Technology Integration Decisions: A Grounded Theory on Instructional Decisions after Professional Development.

Haile, G. A., & Nguyen, A. N. (2008). Determinants of academic attainment in the United States: A quantile regression analysis of test scores. Education Economics, 16(1), 29–57.

Hammerich, K., & Lewis, R. D. (2013). Fish can't see Water. Wiley.

Han, S., & Ma, Y. (2015). A culture–behavior–brain loop model of human development. Trends in Cognitive Sciences, 19(11), 666–76.

Hannafin, M., Land, S., & Oliver, K. (1999). Open learning environments: Foundations, methods, and models. In C. M. Reigeluth (Ed.), Instructional-design theories and models: A new paradigm of instructional theory (Vol. II, pp. 115–140). Lawrence Erlbaum Associates.

Hanson, F. A. (2005). Culture against society. Society, 42(5), 65-68.

Harris, S., Staff, N. A. G. B., Fields, R., & Buckley, N. A. (2013). National Assessment Governing Board.

Harris, D. N., & Herrington, C. D. (2006). Accountability, standards, and the growing achievement gap: Lessons from the past half-century. American Journal of Education, 112, 209–38. https://doi.org/ 10.1086/498995

Hawley, S. R., Chavez, D. V., & St. Romain, T. (2007). Developing a bicultural model for academic achievement: A look at acculturative stress, coping, and self-perception. Hispanic Journal of Behavioral Sciences, 29(3), 283-299.

Holland, J. L. (1963). Explorations of a theory of vocational choice and achievement: II. A four-year prediction study. Psychological Reports, 12(2), 547-594.

Hou, H. T. (2011). A case study of online instructional collaborative discussion activities for problem-solving using situated scenarios: An examination of content and behavior cluster analysis. Computers & education, 56(3), 712-719.

Huang, H.-W., Wu, C.-W., & Chen, N.-S. (2012). The effectiveness of using procedural scaffoldings in a paper-plus-smartphone collaborative learning context. Computers and Education, 59(2), 250–59. https://doi.org/ 10.1016/j.compedu.2012.01.015.

Huang, K., Chen, C. H., Wu, W. S., & Chen, W. Y. (2015). Interactivity of question prompts and feedback on secondary students' science knowledge acquisition and cognitive load. Journal of Educational Technology & Society, 18(4), 159-171.

Huang, R. K., & Springer-Verlag, G. (2016). Ubiquitous learning environments and technologies. Springer Berlin.

Hung, P. H., Hwang, G. J., Lin, Y. F., Wu, T. H., & Su, I. H. (2013). Seamless connection between learning and assessment applying progressive learning tasks in mobile ecology inquiry. Educational Technology & Society, 16(1), 194–205.

Hwang, W.-Y., Chen, H.-R., Chen, N.-S., Lin, L.-K., & Chen, J.-W. (2018). Learning behavior analysis of a ubiquitous situated reflective learning system with application to life science and technology teaching. Educational Technology & Society, 21(2), 137–49.

Janssen, J., Erkens, G., Kanselaar, G., & Jaspers, J. (2007). Visualization of participation: Does it contribute to successful computer-supported collaborative learning? Computers & Education, 49(4), 1037–65. https://doi.org/ 10.1016/j.compedu.2006.01.004.

Jeng, Y. L., Wu, T. T., Huang, Y. M., Tan, Q., & Yang, S. J. (2010). The add-on impact of mobile applications in learning strategies: A review study. Journal of Educational Technology & Society, 13(3), 3-11.

Johnson, D. W., & Johnson, R. T. (1989). Leading the cooperative school. Interaction Book Co.

Jones, V., & Jo, J. H. (2004, December). Ubiquitous learning environment: An adaptive teaching system using ubiquitous technology. In Beyond the comfort zone: Proceedings of the 21st ASCILITE Conference (Vol. 468, p. 474).

Karantinos, N. T. (2009). The Hispanic student achievement gap: An exploratory study of student demographic variables that impact student achievement. Arizona State University.

Karathanos, K., & Mena, D. D. (2009). Enhancing the academic writing skills of ELL future educators: A faculty action research project. English learners in higher education: Strategies for supporting students across academic disciplines, 1-13.

Kayaardi-Hinojosa, N. (2011). The school performance of Hispanic students: A generational approach (Doctoral dissertation, Texas Woman's University).

Kidd, T. T., & Chen, I. (Eds.). (2011). Ubiquitous learning: Strategies for pedagogy, course design and technology. Information Age Publishers.

Koike, H., Sato, Y., & Kobayashi, Y. (2001). Integrating paper and digital information on EnhancedDesk: A method for realtime finger tracking on an augmented desk system. ACM Transactions on Computer-Human Interaction, 8(4), 307–22.

Krapp, A. (1999). Interest, motivation and learning: An educational-psychological perspective. European journal of psychology of education, 14(1), 23-40.

Krashen, S. D. (1981). Bilingual education and second language acquisition theory. Schooling and language minority students: A theoretical framework, 51-79.

Krashen, S. (1992). The input hypothesis: An update. Linguistics and language pedagogy: The state of the art, 409-431.

Krashen, S. (1998). Comprehensible output?. System, 26(2), 175-182.

Kyle. (2017, May 5). SpaceX to launch 4,425 high-speed internet satellites beginning in 2019. https://www.teslarati.com/spacex-high-speed-internet-satellites-2019-launch/

Laborda, J. G. (2015). Ubiquitous learning environments and technologies. British Journal of Educational Technology, 46(6), E32–E33. https://doi-org.libproxy.boisestate.edu/10.1111/bjet.12373

Lewis, R. (2014). How different cultures understand time. Business Insider, 1.

Lewis, R. D. (2010). When cultures collide. Nicholas Brealey Publishing.

Lin, G. H. C. (2008). Pedagogies Proving Krashen's Theory of Affective Filter. Online Submission.

Liu, T. C. (2007). Teaching in a wireless learning environment: A case study. Educational Technology & Society, 10(1), 107–23.

Lin, H. C. K., Chao, C. J., & Huang, T. C. (2015). From a perspective on foreign language learning anxiety to develop an affective tutoring system. Educational Technology Research and Development, 63(5), 727-747.

Looi, C.-K., Seow, P., Zhang, B., So, H.-J., Chen, W., & Wong, L.-H. (2010). Leveraging mobile technology for sustainable seamless learning: a research agenda. British Journal of Educational Technology, 41(2), 154–69.

Lu, C., Chang, M., Huang, Huang, E., & Chen, C.-W. (2010). Context-awareness learning activity generation and its agents in a mobile educational game. In Proceedings of Asia-Pacific Conference on Technology Enhanced Learning (APTEL 2010), Osaka, Japan, September 24–26, 2010, ID. 65.

MacCallum, R. C., & Austin, J. T. (2000). Applications of structural equation modeling in psychological research. Annual Review of Psychology, 51(1), 201–26.

Machado, L. J., & Chung, C. J. (2015). Integrating technology: The principals' role and effect. International Education Studies, 8(5), 43.

Marks, H. M. (2000). Student engagement in instructional activity: Patterns in the elementary, middle, and high school years. American educational research journal, 37(1), 153-184.

Medina, J. (2011). Brain rules: 12 principles for surviving and thriving at work, home, and school. https://readhowyouwant.com.

Miles, M. B., Huberman, A. M., & Saldana, J. (2020). Qualitative data analysis: A methods sourcebook (4th ed.). SAGE.

Miller, E. (1973). Short-and long-term memory in patients with presenile dementia (Alzheimer's disease). Psychological medicine, 3(2), 221-224.

Morales, M. C., & Saenz, R. (2007). Correlates of Mexican American students' standardized test scores: An integrated model approach. Hispanic Journal of Behavioral Sciences, 29(3), 349-365.

Mosher, D. (2019). Elon Musk just revealed new details about Starlink, a plan to surround Earth with 12,000 high-speed internet satellites: Here's how it might work. https://www.businessinsider.com/spacex-starlink-satellite-internet-how-it-works-2019-5

Mouri, K., Ogata, H., Uosaki, N., & Lkhagvasuren, E. (2016). Context-aware and personalization method based on ubiquitous learning analytics. J. UCS, 22(10), 1380–97.

Morin, E. (2005). Ciência com consciência. Bertrand Brasil.

National Health and Medical Research Council (Australia). (2007). Australian code for the responsible conduct of research: Revision of the Joint NHMRC/AVCC statement and guidelines on research practice.

Neufeld, P., Amendum, S. J., Fitzgerald, J., & Guthrie, K. M. (2006). First-grade latino students' english-reading growth in all-english classrooms. Literacy Research and Instruction, 46(1), 23-52.

NGSS for California public schools, K–12. (n.d.). https://www.cde.ca.gov /pd/ca/sc/ngssstandards.asp

Ogata, H., Hou, B., Uosaki, N., Mouri, K., & Liu, S. (2014). Ubiquitous learning project using life-logging technology in Japan. Educational Technology & Society, 17(2), 85–100.

Ogata, H., & Yano, Y. (2004). Knowledge awareness map for computer-supported ubiquitous language-learning. In Proceedings of the International Workshop on Wireless and Mobile Technologies in Education (pp. 19–26). https://doi.org/ 10.1109/WMTE.2004.1281328

Ogata, H., & Yano, Y. (2009). Supporting awareness in ubiquitous learning. International Journal of Mobile and Blended Learning, 1(4), 1–11. https://doi.org/ 10.4018/jmbl.2009090801.

Pea, R. D. (2004). The social and technological dimensions of scaffolding and related theoretical concepts for learning, education, and human activity. Journal of the Learning Sciences, 13(3), 423–51. https://doi.org/ 10.1207/s15327809jls1303_6.

Pratt, H. (2013). Conceptual shifts in the next generation science standards: Opportunities and challenges. Science Scope, 37(1), 6.

Price, S., & Rogers, Y. (2004). Let’s get physical: The learning benefits of interacting in digitally augmented physical spaces. Computers & Education, 43,137–51.

Prigol, E. L., & Behrens, M. A. (2019). Teoria Fundamentada: Metodologia aplicada na pesquisa em educação. Educação & Realidade, 44(3).

Professional Services Close-up. (2013). National assessment governing board reports student achievement. http://libproxy.boisestate.edu/login?url=https://search-proquest-com.libproxy.boisestate.edu/docview/1312356540?accountid=9649

Qualitative research: Grounded theory; What is it? (2019, August 20). https://guides.temple.edu/c.php?g=77914

Rabin, S. (2010). Introduction to game development (2nd ed.). Cengage Learning.

Ravitch, D. (2010). The death and life of the great American school system: How testing and choice are undermining education. Basic Books.

Rockinson-Szapkiw, A. J., Courduff, J., Carter, K., & Bennett, D. (2013). Electronic versus traditional print textbooks: A comparison study on the influence of university students’ learning. Computers & Education, 63, 259–66. https://doi.org/ 10.1016/j.compedu.2012.11.022.

Rogers, Y., Price, S., Randell, C., Fraser, D. S., Weal, M., & Fitzpatrick, G. (2005). Ubi-learning integrates indoor and outdoor experiences. Communications of the ACM, 48(1), 55–59. https://doi-org.libproxy.boisestate.edu/10.1145/1039539.1039570

Saw, G., & Chang, C. N. (2018). Cross-lagged models of mathematics achievement and motivational factors among Hispanic and non-Hispanic high school students. Hispanic Journal of Behavioral Sciences, 40(2), 240–56.

Safavian, N., & Conley, A. (2016). Expectancy-value beliefs of early-adolescent Hispanic and non-Hispanic youth: Predictors of mathematics achievement and enrollment. AERA Open, 2(4), 2332858416673357.

Saye, J. W., & Brush, T. (2002). Scaffolding critical reasoning about history and social issues in multimedia-supported learning environments. Educational Technology Research and Development, 50(3), 77–95.

Schwartz, A. E., & Stiefel, L. (2006). Is there a nativity gap? New evidence on the academic performance of immigrant students. Education Finance and Policy, 1(1), 17-49.

Shih, S.-C., Kuo, B.-C., & Liu, Y.-L. (2012). Adaptively ubiquitous learning in campus math path. Educational Technology & Society, 15(2), 298–308.

Snelson, C, Yang, D., & Temple, T. (In press). Addressing the Challenges on Online Video Analysis in Qualitative Studies: A Worked Example from Computational Thinking Research. The Qualitative Journal.

Song, L. J., Huang, G. H., Peng, K. Z., Law, K. S., Wong, C. S., & Chen, Z. (2010). The differential effects of general mental ability and emotional intelligence on academic performance and social interactions. Intelligence, 38(1), 137-143.

Stevens, T., Olivarez, A., Lan, W. Y., & Tallent-Runnels, M. K. (2004). Role of mathematics self-efficacy and motivation in mathematics performance across ethnicity. The Journal of Educational Research, 97(4), 208-222.

Stevens, T., Olivárez Jr, A., & Hamman, D. (2006). The role of cognition, motivation, and emotion in explaining the mathematics achievement gap between Hispanic and White students. Hispanic journal of behavioral sciences, 28(2), 161-186.

Strauss, A., & Corbin, J. (1990). Basics of qualitative research. Sage publications.

Tan, Q., Huang, Jeng, Y.-L, & Huang, Y. -M. (2010). A collaborative mobile virtual campus system based on location-based dynamic grouping. In Proceedings of the 10th IEEE International Conference on Advanced Learning Technologies (pp. 16–18). IEEE Computer Society Press.

Thomas. (2016, September 29). What Does Immigration Actually Cost Us? The New York Times. https://www.nytimes.com/2016/09/29/opinion/campaign-stops/what-does-immigration-actually-cost-us.html.

Thornberg, R., & Charmaz, K. (2014). Grounded theory and theoretical coding. The SAGE handbook of qualitative data analysis, 5, 153-69.

Trujillo, G., & Tanner, K. D. (2014). Considering the role of affect in learning: Monitoring students' self-efficacy, sense of belonging, and science identity. CBE—Life Sciences Education, 13(1), 6-15.

United States Census Bureau. (2006). Hispanics in the United States.

http://wvm.census.gov/population/www/socdemo/hispanic/files/Internet_Hispanic_in_US

_2006.ppt#434,l,Hispanics in the United States

Usher, E. L., & Pajares, F. (2008). Sources of self-efficacy in school: Critical review of the literature and future directions. Review of educational research, 78(4), 751-796.

Vaughan-Nichols, S. J. (2009). Will mobile computing's future be location, location, location?. Computer, 42(2), 14-17.

Vermunt, J. D. (1996). Metacognitive, cognitive and affective aspects of learning styles and strategies: A phenomenographic analysis. Higher education, 31(1), 25-50.

Vroom, V. H. (1966). Organizational choice: A study of pre-and post-decision processes. Organizational Behavior and Human Performance, 1, 212-225.

Vygotsky, L. (1978). Interaction between learning and development. Readings on the development of children, 23(3), 34-41.

Wang, S. L., & Wu, C. Y. (2011). Application of context-aware and personalized recommendation to implement an adaptive ubiquitous learning system. Expert Systems with Applications, 38(9), 10831–38.

Weiser, M. (1991). The computer for the 21st century. Scientific American, 265(3), 94–105.

Weiser, M. (1993). Some computer science issues in ubiquitous computing. Communications of the ACM, 36(7), 74–83. http://www.ubiq.com/hypertext/weiser/UbiCACM.html

Wells, M., Hestenes, D., & Swackhamer, G. (1995). A modeling method for high school physics instruction. American Journal of Physics, 63(7), 606–19.

Wenglinsky, H. (1997). How money matters: The effect of school district spending on academic achievement. Sociology of Education, 221–37.

Wigfield, A., & Eccles, J. S. (2000). Expectancy–value theory of achievement motivation. Contemporary educational psychology, 25(1), 68-81.

Wikipedia. (2020). Demographics of Taiwan. https://en.wikipedia.org/wiki/Demographics_of_Taiwan

Wong, L. H., & Looi, C. K. (2011). What seams do we remove in mobile-assisted seamless learning? A critical review of the literature. Computers & Education, 57(4), 2364-2381.

Wu, C. H. V., & Beaunae, C. (2014). Personal reflections on cautions and considerations for navigating the path of grounded theory doctoral theses and dissertations: A long walk through a dark forest. International Journal of Social Research Methodology, 17(3), 249-265.

Yang, S. J. H. (2006). Context aware ubiquitous learning environments for peer-to-peer collaborative learning. Educational Technology & Society, 9(1), 188.

Yin, C., Ogata, H., Tabata, Y., & Yano, Y. (2010). Supporting the acquisition of Japanese polite expressions in context-aware ubiquitous learning. International Journal of Mobile Learning and Organization, 4(2), 214–234. https://doi.org/ 10.1504/IJMLO.2010.032637.

Yin, C., Ogata, H. & Yano, Y. (2004) JAPELAS: Supporting Japanese polite expressions learning using PDA towards ubiquitous learning. Journal of Information and Systems in Education, 3(1), 33–39.

Zimmerman, B. J., & Bandura, A. (1994). Impact of self-regulatory influences on writing course attainment. American Educational Research Journal, 1(31), 845–69.

Zimmerman, B. J., & Schunk, D. H. (1989). Self-regulated learning and academic achievement: Theory, research, and practice. Springer-Verlag.

APPENDIX A

AREA154: Apocalypse Division Overview

AREA 154: APOCALYPSE

ADVANCED RESEARCH & EVIDENCE ANALYSIS: CHEMISTRY DIVISION

OVERVIEW & INTRODUCTION

A curricular breakdown of all the content deliver PDFs, topics, pacing, and other information needed to train new agents enrolled in the **AREA154: Apocalypse Division**.

QUALITATIVE EXPERIENCE DATA: THE STUDENT'S VOICES

Josh C. Sophomore	*"This was the greatest chemistry experience ever! Words cannot express how I feel about this class."*
Cesar Q. Junior (ELD)	*"The best class in the world. The best class that I have had."*
Annon (male)	*"The experiences I had felt in this class were the most fun, crazy, and life lesson (filled) of all my classes. I will take these skills with me to use in the world if ever there is a catastrophe."*
Georgia M. Junior	*"I had no idea any of this was even a thing! An amazing class."*
Annon (Female)	*"This class is the best class I ever had. This environment is very creative, the lights, the notebooks, the tech and a whole lot of things."*
Anthony M. Sophomore	*"This was my best class! To those coming next year, if you think you are ready for this... You are NOT READY! This stuff is crazy!"*
Natalie S. Sophomore	*"I wasn't expecting my science class to be this amazing. I learned so many things that made me think about what can happen in the world."*
Laelanie I. Sophomore	*"You have opened my eyes to so many things that I would have never thought of. Chemistry was not boring at all even though I didn't really talk much."*
Brandon C. Sophomore	*"Keep teaching this way because it makes learning fun and actually interesting. This was my most fun class; it opened my eyes to the real world."*
Ryan O. Sophomore (SpEd)	*"This is the world's best science class."*
Annon (Male)	*"I really enjoyed this class. I don't normally like science but this class made me enjoy it. This was my favorite class this year. I learned so much because you were teaching what actually grabbed my attention. I felt included even though I don't talk a lot."*

About the student feedback: *Students were told that I (the researcher) would not be reading any feedback forms until 2-days after school was out for the summer. At the time of the feedback grades, finals, and all work had been completed. Students knew their grades . Students were not encouraged to put their names on the feedback form, however some did so on their own accord. The course feedback was completely voluntary, done on paper, and students were encouraged to be honest.*

QUALITATIVE EXPERIENCE DATA: THE STUDENT'S VOICES

John O.
Sophomore

"It didn't take long to realize that this was going to be my favorite class. I would always come home and tell my family what we were learning. They think you're nuts, but every one of them would sign up to be in here if they could. You taught me to have an open mind set and always ask questions. That will always help me."

Shailah W.
Sophomore

"This was a once in a life time experience."

Annon (Male)

"I would take this class again. I learned chemistry and lots of stuff that wasn't chemistry."

Emelina M.
Junior

"Science is my favorite subject and you made me love it even more. I feel accomplished having finished the program."

Annon (Male)

"Krav Maga in a chemistry class! That's crazy! You for real opened my eyes to everything I thought I knew. This was my favorite class of my whole life."

Emiliy G.
Sophomore

"I've never had a class like this. I felt supported and helped. Even my parents wanted to take the class.

Zach L.
Sophomore

"I was challenged by the projects but understood the notes better in this class."

Ariana H.
Sophomore

"I thought this class (chemistry) was going to be a pointless class. After I started learning, I realized this was the only class that was going to teach me how to function in a crisis. I feel stronger knowing this."

Annon (Male).
Sophomore

"My other classes were very dull and just worksheets but this class was very fun I wish I could have it again! This class made me feel like I could maybe be some-one and actually learn and not feel dumb."

Leslie S.
Sophomore

"This class taught me how to work with others and bond as a team."

Staciah M.
Sophomore

"People said chemistry was hard. The feeling of success in chemistry was great because it was easier for me to learn and I actually have know how to do some actual chemistry."

QUALITATIVE EXPERIENCE DATA: THE STUDENT'S VOICES

Lindsay J. Sophomore	*"I thought the Examulations were really cool, because they tested us under a real simulated disaster. The test was like trying to survive in real life and not just a test with paper and pencil."*
Stephanie T. Sophomore	*"Knowing this survival science makes me feel powerful. Like, people need me."*
Robert S. Junior	*"If there were an AREA154 class of any other subject, I'd totally sign up for it."*
Annon (Male)	*"Thank you for pushing us and telling us about the REAL world. Though half of that stuff scared the crap out of me."*
Leo R.	*"I had in interest in some of these conspiracies theory, but this class put the science to the stories. The survival part has more importance when the conspiracies have some validity."*
Maria V. *Sophomore*	*"I don't mind hard if the subject is interesting. This class was both!"*
Angel L. Sophomore	*"An incredible year that was full of surprises and lots of fun. I will certainly neve forget this class."*
Jasmine G. Sophomore	*"Everyday I can't wait to go to your class. The crazy stuff in this class always turns my day around."*
Michael L. Sophomore	*"I had a great experience in this class. I wish I could have this class next year!"*
Azul C.. Sophomore	*"Chemistry was way easier to learn when there was a point to learning it."*
Deliliah M. Sophomore	*"The AREA154 system helped me catch up when I had to spend time dealing with family stuff. The flexibility to work at my pace made it so I didn't fail out of the class. Retakes and achievements helped save my grade."*

ALIGNMENT: **NGSS SCIENCE STANDARDS**

UNIT I ______________________________________

Evidence Statement PS-1:	Use Mathematical representations to support the claims that atoms, and therefore mass, are conserved during a chemical reaction.
NGSS Performance Clarification:	***HS-PS1-7 Matter and its Interactions*** Emphasis is on using mathematical ideas to communicate the proportional relationships between masses of atoms in the reactants and the products, and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale. Emphasis is on assessing students' use of mathematical thinking and not on memorization and rote application of problem-solving techniques.
Essential Outcomes:	Students will: Conduct an investigation to generate circumference and volume data for modeling the amount of ash deposited on North America.
Laboratory Exercises / Activities:	Calculating the volume of ash deposited on North America using Google earth to obtain circumference of different ash layers, assuming mass is conserved, the volume of magma in the chamber should equal the volume of ash deposited.

Evidence statement PS-2:	Construct and revise an explanation for the outcome of a simple chemical reaction based on the outer-most electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.
NGSS Performance Clarification:	***HS-PS1-2 Matter and its Interactions*** Examples of chemical reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen.
Essential Outcomes:	Students will: Conduct an investigation to generate circumference and volume data for modeling the amount of ash deposited on North America.
Laboratory Exercises / Activities:	Calculating the volume of ash deposited on North America using Google earth to obtain circumference of different ash layers, assuming mass is conserved, the volume of magma in the chamber should equal the volume of ash deposited.

Evidence statement ESS1-5:	Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks.
NGSS Performance Clarification:	***HS-ESS1-5 Earth's Place in the Universe*** Emphasis is on the ability of plate tectonics to explain the ages of crustal rocks. Examples include evidence of the ages oceanic crust increasing with distance from mid-ocean ridges (a result of plate spreading) and the ages of North American continental crust decreasing with distance away from a central ancient core of the continental plate (a result of past plate interactions
Essential Outcomes:	Students will: Research tectonic movement of magmatic hots pots to predict the direction of movement and estimated time line of the Yellowstone Caldera eruption cycle to generate a model that predicts the potential threat of an eruption in the near future.
Laboratory Exercises / Activities:	Not assigned.

Text Source(s):
California Science Framework http://www.cde.ca.gov/ci/sc/cf/scifwprepubversion.asp
Preliminary California Next Generation Science Standards Core Content Connectors
http://www.cde.ca.gov/ta/tg/ca/documents/ngssaltconnectors.pdf

ALIGNMENT: **NGSS SCIENCE STANDARDS**

UNIT I (Cont.)

Evidence Statement ETS1-2:	Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. (STEM application).
NGSS Performance Clarification:	***HS-ETS1-2 Engineering and Design*** Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations.
Essential Outcomes:	Students will: Use the engineering designs and eventually choose one to use as a guide for building devices that will produce fresh drinking able water from water that has been compromised by acid rain and physical contaminants.
Laboratory Exercises / Activities:	Design and build a device that can eliminate dissolved NaCl (a product from the neutralization reaction) to make pure drinking water.

UNIT 2 ______________________________

Evidence statement PS-1:	Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.
NGSS Performance Clarification:	***HS-PS1-1 Matter and its Interactions*** Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.] [Assessment Boundary: Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.
Essential Outcomes:	Students will: Use the trends on the periodic table to create reactions that will produce vast amounts of heat.
Laboratory Exercises / Activities:	Not assigned.

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Evidence statement PS1-2:	Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.
NGSS Performance Clarification:	***HS-PS1-2 Matter and its interactions*** Examples of chemical reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen
Essential Outcomes:	Students will: Use the trends on the periodic table to create reactions that will produce vast amounts of heat.
Laboratory Exercises / Activities:	Not assigned.

Text Source(s):
California Science Framework http://www.cde.ca.gov/ci/sc/cf/scifwprepubversion.asp
Preliminary California Next Generation Science Standards Core Content Connectors
http://www.cde.ca.gov/ta/tg/ca/documents/ngssaltconnectors.pdf

ALIGNMENT: NGSS SCIENCE STANDARDS

UNIT 2 (Cont)

Evidence statement ESS3-1:	Constructing Explanations and Designing Solutions that are supported by multiple and independent student-generated sources of evidence consistent with scientific knowledge, principles, and theories of the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.
NGSS Performance Clarification:	***HS-ESS3-1 Earth and Human Activities*** Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.
Essential Outcomes:	Students will: Use local and national data to assess the community's decision to support continued usage of local soil and mineral resources that will lead to a key information that will determine if the land is workable or does the community need to move on to areas in other parts of the country.
Laboratory Exercises / Activities:	Create and use a simple soil texture analyze and analyze soil from three different areas of the local community. Based on the findings, students make decisions about staying in the area or going elsewhere.

Evidence statement ESS3-4:	Evaluate or refine a technological solution that reduces impacts of human activities on natural systems
NGSS Performance Clarification:	***HS-ESS3-4 Earth and Human Activities*** Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geo-engineering design solutions
Essential Outcomes:	Students will: Analyze the chemical production processes of organic fuels to acquire efficient means of refining fuels that will serve as sources of fuel in the event of a large scale shortage.
Laboratory Exercises / Activities:	Create a simple still out of thick sport bottles, straws and some warm water. Corn can be catalyzed using alpha-amylase into ethanol and recovered to provide a source of fuel.

UNIT 3

Evidence statement PS1-4:	Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.
NGSS Performance Clarification:	***HS-PS1-4 Matter and its interactions*** Emphasis is on the idea that a chemical reaction is a system that affects the energy change. Examples of models could include molecular-level drawings and diagrams of reactions, graphs showing the relative energies of reactants and products, and representations showing energy is conserved.
Essential Outcomes:	Students will: Present calculations showing the breaking of bonds in reactants and the difference in the bond energy of the products to illustrate which alkali or earth alkali metals would best fit the desired function for the reaction.
Laboratory Exercises / Activities:	Not assigned.

Evidence statement PS1-5:	Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.
NGSS Performance Clarification:	***HS-PS1-5 Matter and its Interactions*** Emphasis is on student reasoning that focuses on the number and energy of collisions between molecules.
Essential Outcomes:	Students will: Apply Le Chatelier's Principle to Their own physical trials that will provide physical feedback on how their body's carbon dioxide and oxygen equilibrium are affected by changing concentrations of each.
Laboratory Exercises / Activities:	Using students, a bluetooth heart rate monitor, students can establish insight into their own CO_2 / O_2 equilibrium.

ALIGNMENT: NGSS SCIENCE STANDARDS

UNIT 3 (Cont)

Evidence statement PS1-6:	Constructing Explanations and Designing Solutions that are supported by multiple and independent student-generated sources of evidence consistent with scientific knowledge, principles, and theories of the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.
NGSS Performance Clarification:	***HS-PS1-6 Matter and its Interactions*** Emphasis is on the application of Le Chatelier's Principle and on refining designs of chemical reaction systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products.
Essential Outcomes:	Students will: Apply Le Chatelier's Principle to Their own physical trials that will provide physical feedback on how their body's carbon dioxide and oxygen equilibrium are affected by changing concentrations of each.
Laboratory Exercises / Activities:	Using students, a bluetooth heart rate monitor, students can establish insight into their own CO_2 / O_2 equilibrium.

Evidence statement PS4-1:	Evaluate or refine a technological solution that reduces impacts of human activities on natural systems
NGSS Performance Clarification:	***HS-PS4-1 Waves and Their Applications in Technologies for Information Transfer.*** Examples of data could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth.
Essential Outcomes:	Students will: Test electromagnetic signal energy to acquire information about the transmissibility of different materials so that will key decisions can be made about which materials to use for reflecting an EM signals and which to be used for blocking them.
Laboratory Exercises / Activities:	Students evaluate the penetrability of different types of materials by putting their cell phones inside each one and then trying to call it. The results indicate which materials can be used to protect yourself from a prion activation signal.

Evidence statement PS4-2:	Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.
NGSS Performance Clarification:	***HS-PS4-1 Waves and Their Applications in Technologies for Information Transfer.*** Examples of advantages could include that digital information is stable because it can be stored reliably in computer memory, transferred easily, and copied and shared rapidly. Disadvantages could include issues of easy deletion, security, and theft.]
Essential Outcomes:	Students will: Test electromagnetic signal energy to acquire information about the transmissibility of different materials so that will key decisions can be made about which materials to use for reflecting an EM signals and which to be used for blocking them.
Laboratory Exercises / Activities:	Students use the data from the prior experiment to construct a helmet or structure using the ascribed materials that could protect themselves. Materials must be proven to block 3G signals 4G would be even better, but considered a bonus.

Text Source(s):
California Science Framework http://www.cde.ca.gov/ci/sc/cf/scifwprepubversion.asp
Preliminary California Next Generation Science Standards Core Content Connectors
http://www.cde.ca.gov/ta/tg/ca/documents/ngssaltconnectors.pdf

ALIGNMENT: NGSS SCIENCE STANDARDS

UNIT 4 (Cont)

Evidence statement PS1-3:	Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles
NGSS Performance Clarification:	***HS-PS1-3 Matter and its Interactions*** Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). Examples of bulk properties of substances could include the melting point and boiling point, vapor pressure, and surface tension
Essential Outcomes:	Students will: Use different methods for calculating density to acquire the density of objects that have oddly shaped structures that will provide given information about specific qualities of a given material because of its unique density.
Laboratory Exercises / Activities:	Students are presented with a wide collection of materials of different masses, shapes, and densities. Students use measurements and volumetric analysis to rank the materials that are both real and theoretical.

Evidence statement PS1-2:	Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.
NGSS Performance Clarification:	***HS-PS1-2 Matter and its Interactions*** Examples of chemical reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen
Essential Outcomes:	Students will: Use a cutting edge nuclear synthesis concept called "Island of Stability" to make predictions about the atomic and nuclear attributes of the much larger engineered atoms.
Laboratory Exercises / Activities:	Students are presented with a wide collection of materials of different masses, shapes, and densities. Students use measurements and volumetric analysis to rank the materials that are both real and theoretical.

UNIT 5

Evidence statement PS1-8:	Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.
NGSS Performance Clarification:	***HS-PS1-8 Matter and its Interactions*** Emphasis is on simple qualitative models, such as pictures or diagrams, and on the scale of energy released in nuclear processes relative to other kinds of transformations.
Essential Outcomes:	Students will: Use computer simulation software to analyze the degradation of nuclear material over time to provide a risk assessment for remaining in a specific area that has been soaked with various types of radiation.
Laboratory Exercises / Activities:	Not assigned.

Evidence statement PS2-3:	Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.
NGSS Performance Clarification:	***HS-PS1-2 Matter and its Interactions*** Examples of evaluation and refinement could include determining the success of the device at protecting an object from damage and modifying the design to improve it. Examples of a device could include a football helmet or a parachute.
Essential Outcomes:	Students will: Adapt the energy of kinetic motion to that of the energy of sub-nuclear radioactive particles to procure a potential solution for preventing prolonged exposure and increasing protection from nuclear radiation.
Laboratory Exercises / Activities:	Optionally assigned.

ALIGNMENT: NGSS SCIENCE STANDARDS

UNIT 5 (Cont) ____________________________________

Evidence statement PS3-1:	Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known
NGSS Performance Clarification:	***HS-PS3-1 Energy*** Emphasis is on explaining the meaning of mathematical expressions used in the model.
Essential Outcomes:	Students will: Utilize a computer simulation on nuclear impact zones to calculate the amount of destruction at varying levels of yield to acquire an understanding of the impact of "height of detonation" can have on a target of nuclear attack.
Laboratory Exercises / Activities:	To visit the online simulator for nuclear yield testing, visit nukemap.com.

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Evidence statement ETS1-4:	Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.
NGSS Performance Clarification:	***HS-ETS1-4 Engineering Design*** Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponential and logarithmic, in conjunction with computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. Use mathematical models and/or computer simulations to predict the effects of a design solution on systems and/or the interactions between systems
Essential Outcomes:	Students will: Utilize a computer simulation on nuclear impact zones to calculate the amount of destruction at varying levels of yield to acquire an understanding of the impact of "height of detonation" can have on a target of nuclear attack.
Laboratory Exercises / Activities:	To visit the online simulator for nuclear yield testing, visit nukemap.com.

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Evidence statement PS2-5:	Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current. (STEM Applications).
NGSS Performance Clarification:	***HS-PS2-5 Forces and Interactions*** Assessment is limited to designing and conducting investigations with provided materials and tools.
Essential Outcomes:	Students will: Use basic instruction on electrochemical batteries to create a electromagnetically driven motor to achieve a small amount of work when only using spare metallic sources routinely found around the house.
Laboratory Exercises / Activities:	Using only simple metallic components to create an electric current, students will build a galvanic battery which would involve making judgements about the E-cell value for the anodes and cathodes to maximize cell voltage. A successful electrochemical cell system outputs more than 2.0v and easily lights an LED.

OPTIONAL ADDITIONAL UNIT
(Currently added to AS:02)____

Evidence statement PS2-1:	Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration
NGSS Performance Clarification:	***HS-PS2-1 Motion and Stability: Forces and Interactions*** Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object sliding down a ramp, or a moving object being pulled by a constant force.
Essential Outcomes:	Students will: Use basic instructions on newton's laws of motion, drag aerodynamics, and the ideal gas law to design through experimentation a rocket that is maximized for distance to provide a physical model that can minimize drag and maximize the force generated by a compressed gas.
Laboratory Exercises / Activities:	Optionally assigned.

ALIGNMENT: NGSS SCIENCE STANDARDS

OPTIONAL ADDITIONAL UNIT
(Currently added to AS:02)______________________________

Evidence statement PS2-1: Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration

NGSS Performance Clarification: ***HS-PS2-1 Motion and Stability: Forces and Interactions***
Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object sliding down a ramp, or a moving object being pulled by a constant force.

Essential Outcomes: Students will:
Use basic instructions on newton's laws of motion, drag aerodynamics, and the ideal gas law to design through experimentation a rocket that is maximized for distance to provide a physical model that can minimize drag and maximize the force generated by a compressed gas.

Laboratory Exercises / Activities: Students pressurize rockets and study the application of the basic gas laws to maximize the distance a rocket travels while also minimizing the drag.

Additional help with building and predicting rocket distances, this online simulation could be used to help.

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Evidence statement ETS1-4: Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

NGSS Performance Clarification: ***HS-PS2-5 Forces and Interactions***
Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

Essential Outcomes: Students will:
Same as above

Laboratory Exercises / Activities: *Same as above*

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Evidence statement PS2-3: Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision

NGSS Performance Clarification: ***HS-PS2-3 Motion and Stability: Forces and Interactions***
Examples of evaluation and refinement could include determining the success of the device at protecting an object from damage and modifying the design to improve it. Examples of a device could include a football helmet or a parachute.

Essential Outcomes: Students will:
Same as above

Laboratory Exercises / Activities: *Same as above*

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Assessment of Standards:

Unit 1 (Summative): Examulation (A simulation that assess knowledge through simulation) / Teaining SRTs 1-4 (Formative)
Unit 2 (S): Examulation (A simulation that assess knowledge through simulation) / Teaining SRTs 1-4 (Formative)
Unit 3 (S):Examulation (A simulation that assess knowledge through simulation) / Teaining SRTs 1-4 (Formative)
Unit 4 (S): Examulation (A simulation that assess knowledge through simulation) / Teaining SRTs 1-4 (Formative)
Unit 5 (S): Examulation (A simulation that assess knowledge through simulation) / Teaining SRTs 1-4 (Formative)
Summative (1): Fall Semester Final - Digitally deployed through the website
Summative (2): Spring Semester Final - Digitally deployed through the website.

RIGOR, RELEVANCE, & RELATION

Rigorous, Relevant & Relational Curriculum

Rigor, relevance and relational, (the three - R's of the Common Core philosophy)are also at the root of the NGSS design principles. These come to life through the use of advanced web-based technology that empowers the students to have a sense of control over the distribution of the content and the rate at which they traverse the learning material... All while learning how to survive the end of everything!

The Three R's Applied

The AREA154: Apocalypse Division curriculum provides access to researched based real-world situations that require the students to utilize a wide range of analytical skills and internet search techniques to acquire the key pieces of support information. In turn, this information then becomes important cognitive scaffolding for learning and remembering chemical and physical science curriculum. "An impression may be so exciting emotionally as almost to leave a scar upon the cerebral tissue" (James, 1890. p670). James wrote this quote some 120 years ago, and this statement still applies to our own experiences today. While the science classroom may not present the same level of emotional excitement as a car accident, being robbed, winning the lottery or a first kiss, experimental evidence strongly suggests that emotional impact affects memory and recall.

Experiments conducted by Leventon (2005) on the impact of emotional, sensory input and memory provided evidence that not only does emotionally intense input increase recall, but children of different ages are affected differently. In an experiment conducted for his dissertation, children between the ages of 7 and 11 and another group between 9 and 12 years-old. Both groups experienced a series of emotionally intense emotionally neutral images. The researchers then split the emotionally intense images into negative and positive emotional stimuli. Upon exposure to those images, at the fMRI module upon the students head would register the electromagnetic signal produced by the temporal lobe. The intense of the electrical signal, which occurs very close to 300 milliseconds after exposure. This signal was designated the p300 peak, and it was used as a reference to indicate the intense it of any emotional impact felt by the viewer (Hajcak, MacNamara, & Olvet, 2010). The results of these experiments indicated a statistically significant connection between negative images and older students and positive emotional images and younger students.

Leventon did not provide any experimental data to explain the results, however, hypothesized about the cause. The suggestion centered around the maturity of the brain's neural wiring. Younger students do not have the advanced neural brain wiring that older students possess (2010). High school students, being at the older end of the experimental data pool, would most likely appear more sensitive to emotionally negative (fear, anxiety, threats to safety) than they would other stimuli represent more positive emotions (love, comfort, joy).

A NEW KIND OF STUDENT

A New Kind of Student:

The volume of studies done on the affect of lower income on academic performance has always produced the same conclusion. Lower income students are far less likely to succeed in school. The research on identifying a cause or causes for this result are far less conclusive. Laccor and Tissington (2011) revealed that among the members of a low SES student's family the mother has the most impact on the students perceptions and success academically. Furthermore, the study also indicated that students from wealthier homes participated in far more experience building activities than low income peers. This data, along with other studies that have linked learning with life experiences, the operational philosophy in AREA154 is to build the educational experience around the experiential schemata that Hollywood has produced for the students.

There is nothing inherently broken about "traditional" science curriculum. However, several factors stand in the way of student engagement. The list provided here is a short view into some engagement blocks that derail students' ability to engage in a more traditional curriculum:

"Life experience"

The life experiences encourage and promote new neural connections that open the brain up to new possibilities, new information, and making new connections. As the brain will do this automatically if there is enough information for the student to solve the dissonance, low SES students will resist this task. The resistance doesn't come out of spite or oppositional defiance, it originates from not thinking one has the capacity to make the connections and have the information stick. More life experiences mean more neurosensory data to attach academic learning to and be able to retain it.

"Stimulus competition"

In wildly increasing numbers, students are diverted from classroom learning by activities on their personal devices of Chromebook that have a far greater emotional return. Traditional curriculum is just hopelessly outgunned and without a significant emotional stimulus at home (i.e. parents) willing to make school success more emotionally gratifying than Instagram. The 'drama' of this program was designed to help give learning a new dramatic edge to keep learners engaged.

"Comfort forces forgetting"

The AREA154: Apocalypse Division curriculum design attempts to destabilize ones sense of comfort in an attempt to use that dissonance to motivate students to want to know how to survive. Beyond race, religion, language, gender, or species the drive to survive is very strong. The program then attempts to utilize situational emotion to help embed factual information.

The following list provides a summative analysis of each segment of the AREA154: Apocalypse Division curriculum. Additionally, each content area will have specific examples of course rigor, relevance, and social collaboration with peers both inside the class and outside the class.

THE YELLOWSTONE CALDERA (SUPER VOLCANO)

AGENT TRAINING: AS:01
Case File: “Apocalypse By Caldera (Super Volcano)

Case Summary:

Over the last ten million years or so, the Yellowstone caldera has erupted every 600,000 years or so. As it stands currently, the United States is about 64,000 years over due. As the class begins the study, we explore what would happen if it erupts. We compare the energy release to that of many of the most immense nuclear explosions ever recorded. From there the United States, primarily the East coast erodes into chaos. The training covers the impact of inhaling micro particles of volcanic ash and the concrete-like substances that forms in the lungs. Then the water supply is compromised, and only the few know how to tell the good water from the water that might kill thousands of survivors. Finally, learn how to develop devices to neutralize and clean the water for the good of all.

STEM Experiences:

The caldera (super volcano) scenario has been played out in movies, comics, and video games for decades. However, large cognitive gaps remain about what volcanic ash is and how it differs from ash produced from a fire. In this case file, students build a set of simulatory lungs and expose these moist tissues to concrete ash (compositionally very close to volcanic ash) to observe the chemical influence volcanic ash has on animal lungs.

Additionally, the agents are faced with fresh water shortages due to the volcanic gasses disrupting the availability of drinking water. Agents design and build distillation devices that demonstrate how to not only neutralize acidified volcanic water, but separate the fresh water from the resulting saltwater. This skill could save lives in a number of different scenarios.

This list represents the key topics delivered to the students:

Chemical Focus Points
Thermodynamics
Units of energy / unit analysis
Structural analysis
Thermochemical reactions
Phase changes of matter
Hydration reactions of concrete
Metric analysis of energy units

Additional Focus Points
Volumetric analysis
Ratios and unit comparison
Google Earth - measurement tools

THE ECONOMIC COLLAPSE

AGENT TRAINING: AS:02
Analysis of Case: "The Economic Collapse"

"The bill comes due, always."
- Mordo (Dr. Strange, 2017, Marvel Cinematic Universe)

Case Summary:

Marvel Studios, aside from its obvious entertainment value, has moments where universal truths fall from the mouths of the characters. This quote from the movie represents the intensely fragile nature of the US economy. For decades the United States government has used the Federal Reserve to write checks for currency that was not backed by anything material. Only our faith in the US Dollar and the idea that the US can pay it's bills keeps the US currency alive. However, less obviously, the US has managed influenced the OPEC nations to only see oil in US Dollars in exchange for military support. This, along with several moves by British Banks made in 1934 to suggest that the US Dollar be used as the world reserve currency, created the foundation for the "Petro-Dollar". In this world altering scenario, an technology known as ground penetrating sonography, or seismic topography, discovers that the world's oil reserves have been dramatically over estimated and nearly depleted. As a result, the world panics, the US Dollar becomes worthless, the economy crashes, and the money under the mattress isn't worth the paper it's printed on. So, now what?

This case file begins with the understanding that no one is at because no one can be paid, gasoline is $400 a gallon, and it's only a matter of weeks before panic sets in and the common person starts to become desperate. As emergency services are tasked to exhaustion, the one additional bonus disaster begins to rear it's head: Viral outbreak! In the final training of the case file the students are tasked with using their knowledge of chemical gas laws, pressure, forces, and aeronautical engineering skills to design a pressurized water rocket capable of delivering anti-viral medication into the "Hot Zone".

STEM Experiences:

This case file requires the most materials and hands on time to complete. The students understanding of gas laws, pressure, forces of flight and other integrated sciences comes from students generated theory, student-lead design and building, student-lead testing, and student-lead revision, rebuilding, and retesting.

This list represents the key topics delivered to the students:

Science Focus Points
Identification of alkali metals on periodic table
Properties of alkali metals
Thermochemical reactions
Ideal Gas Law
Gay-Lussac Law
Boyles Law
Aeronautical forces of flight
Scientific experimental process
Engineering designing principles

Additional Focus Points
Math process - Percent composition
Basic principles in aeronautical forces
Read soil composition triangle diagrams
Distance acquisition using digital tools

THE ZOMBIE APOCALYPSE

AGENT TRAINING: AS:03
ANALYSIS OF CASE FILE: HYPER-INFECTIOUS PATHOGEN (PRION INFESTATION)
AKA: *THE ZOMBIE APOCALYPSE - and yes, it could happen.*

Case Summary:

Beginning as far back as the 1960s the US government has been playing with the idea of mind control as evident by the now declassified documents found online about the MK-ULTRA program. As the program was de-funded, MI-6 in conjunction with the CIA developed a nanometer sized tool that was susceptible to microwave and radio wave electromagnetic energy. The hope was to use this Barium - Strontium complex peizo crystal to create an electrical current into a protein substrate. The electrical current then creates changes in the proteins tertiary structure. According to the study, a specific and still unclassified electromagnetic wave (radio wave most likely) triggered the piezo crystal to induce the altered state of these brain proteins. Proteins are a lot like keys to a door. When the shape is altered, so is their function. This nanotechnology became known as a *the prion*, and the effect it had on the livestock was eventually dubbed the "Mad Cow" disease.

The mythology of the "zombie" is physiolocially impossible, as modern medical science understands the phenomenon. There is, however, an alternative adaptation to this story that is plausible, in fact we see spongiform ecephalopathy in the general public all the time in the form of brain wasting conditions like Alzheimerz. The prions and the attached atomic sized peizo crystal appear to leach the copper ions from the cerebral cortex of the brain. Over time, the brain would lose its thinking functions and resort to the more impulsive and torrential uncontrolled rat-brain. This deterioration was constitute zombie-like behavior. Not exactly like the mythology, but still frightfully possible. In the 1980s world wide propagation of such a radio wave would be impossible. However, in our modern era of cellular and satellite communication a world wide radio signal could be broad cast to nearly every person on the planet.

STEM Experiences:

The search: Divided into teams of 2-3 students used a smart phone app to collectinformation about the EMF signals surrounding materials commonly found in construction materials. Students form assumptions and theories about the electromagnetic permeability of each material and whether or not a signal can be received by the phone inside. Agents then begin to see that materials are not all created equal when electromagnetic waves are concerned. Using this information, agents begin to formulate plans to keep their own cerebral cortex safe from prion activation.

This list represents the key topics delivered to the students:

Chemical Focus Points
The electromagnetic spectrum
Wavelength, frequency, energy of EM waves
Chemical equilibrium
Le Chatelier's Principles of equilibrium
E = ln calculationsof energy, frequency,
wavelengths of EM radiation.

Additional Focus Points
Active participation in learning Krav Maga
Metric unit analysis

Algebraic calculations

THE FALSE FLAG ALIEN INVASION

AGENT TRAINING: AS:04

CASE FILE: "ALIEN INVASION" - A FALSE FLAG OPERATION.

Case Summary:

In 2005 During a joint mission between NASA and the ESA (European Space Agency) a pair of satelites called the GRACE TWINS were lauched to analyze gravitational oddities on Earth. What was found was quickly classified and only released recently to the public. The gravitational analysis suggest there was an impact in the south pole about 13-14,000 years ago. Normally, impacts of this type vaporize the meteorite. Not in this case. Whatever made that impact creator is still there! The evidence suggests the presence of a material far more dense than anything on the current periodic table; Something stong enough and dense enough to survive interstellar travel. The supposition of this advanced material sets the backdrop for the analysis of atoms, chemical structures, and the nature of mater on this planet. Sumerian, Egyptian, Mayan tablets and enscriptsions all point to the same thing. We are not alone and have not been for a very long time and someone is planning their return.

Dr. Steven Green, researcher, has spent the last 30 years diving into the depths of compartmentalized government projects. In his assessment, the real threat won't be actual "extra-terresterial Biological Entities" or EBNS (eee-bins). The threat would likely come from, us?? For years, dating back to Pres. Reagan's address to the United Nations back in 1983 may have worried about the possibility of a false-flag operation in order to pull all of the feuding political factions together under one roof. Whether the threat comes from above or originates from our own backyard, the effects will be devastating.

The STEM Experience:

In the event of an "invasion" the first step is to gather information. Agents collect a wide variety of unique materials and utilize STEM tools to determine the density of these newly found objects. Eventually, students locate very specific types of exothermic and endothermic reactions that could be used to help defend humanity from any sort of invasion.

This list represents the key topics delivered to the students:

Chemical Focus Points

Avogadro's number
Conversions between mole and particle
Chemical formulation & Naming
Writing names from formulation
Group ions - names & formulas
Ionization
Atomic structure
Periodic table organization
"Island of Stability" - Theory
Chemical reaction applications

Additional Focus Points

Dr. Steven Greer - Military ind. complex
Sumerian & Egyptian archeological history
Aztec & Mayan archeological history
Geographical & gravitational analysis of Antarctica
Crust displacement theory & tectonics

GLOBAL THERMONUCLEAR WAR

AGENT TRAINING: AS:05
CASE FILE: "GLOBAL THERMONUCLEAR WAR"

Case Summary:

Since the initial detonation at the Trinity test site at White Sands New Mexico, the world learned to tremble at the feet of the most devastating weapon the world had ever seen. To this day, the threat of a global thermonuclear event looms over everyone. In this case, the phenomenological story line begins with an extremist group called Al-Gebra (yes, like the math and done on purpose - because math seems to terrorize a lot of people!) acquires a multitude of nuclear weapons and intends to use them to "reset" humanity. This "situation" was chosen due to it being far more likely than to become come a threat than any nation-state such as Russia or China.

This case file analyzes the nature of radioactive fallout, nuclear radiation, and the bio-logical effects that would likely be experiences in the event one was present in a nuclear debris field.

However, there is one more threat that we were not as vulnerable to back in the cold war as we are now. The threat of an EMP (electromagnetic pulse) looms to wreck untold havoc on electronic devices everywhere. As the last high-altitude nuclear test was during Operation Fishbowl where "Starfish Prime" was detonated off the coast of Hawaii 57 years ago. In addition to the radiation, our agents also have the burden of finding ways to protect key electronic components that would give them an edge in an apocalypse level event.

The STEM Experience:

Nearly every home in America has the materials needed to create a mask that could keep fine particles of dust and nuclear radiation out of one's lungs long enough to get out of the effected area. Agents design and build this key tool. Additionally, agents design and build devices (some of which are callbacks to AS:03) to shield phones and computers prior to class one, two, or three EMP events. These Agents will have applicable skills to apply in times of intense need.

This list represents the key topics delivered to the students:

Chemical Focus Points
Nuclear decay cycles
Manipulation of the half-life equation
The role of the proton in nuclear stability
Identification of types of nuclear decay
The ^{238}U nuclear decay series
Gamma radiation
Beta radiation
Alpha radiation
E electromagnetic Pulses (EMPs)

Additional Focus Points
Algebraic calculations
Measuring and comparing atomic yields
Analyzing simulated EMP attacks
Coronal mass ejections (solar EMPs)

AREA 154 :APOCALYPSE
ADVANCED RESEARCH & EVIDENCE ANALYSIS: CHEMISTRY DIVISION

ACHIEVEMENTS & THE LEADER BOARD

Achievement Points: Experimental Motivation System
Designed and built by: Torrence Temple

Summary: Not all students are motivated by the utterance of a teacher to complete work. Telling a low SES student to simply "try harder" will often fall on deaf ears. Implementing modern gameification theory into a classroom curriculum has often been talked about but rarely implemented, especially in something as dry and clinical as chemistry. This section presents a web-based achievement system that was used to encourage students (agents-in-training) to increase their "rank" by accomplishing challenges above and beyond the expectations of the prescribed curriculum.

ACHIEVEMENTS, RANK, & MOTIVATION

AGENT RANKING

Special Access "Rookie Agent" ID Badge - Used for achievements, rank, & attendance.

At the beginning of the year each student's picture was taken and put on a custom made Access Badge ID card (an optional add-on for the program). That they would acquire at the beginning of every class and keep on them until the class was over and they would return the badge to the class hanging area. Each student began at the beginning stages of the agent ranking program, which was simply defined as, "Agent".

The students could move up their ranking by accomplishing any number of activities during the course of the training year. Some of these areas of achievement

Included:

Achievement Type Point Value
100% Achievements (For SRTs -quizzes) 15 pts
Completion of a case file 10 pts
Graffiti Achievements 30 pts
Spec-Ops Achievements 40 pts
Q - Gadget Achievements 40 pts
Truth Achievements 20 pts
Hands-up Achievements 5 pts
Team Player Achievements 5 pts
The achievements expand as opportunities for building creative and engaging projects and challenges arises.

Below is a basic description of each category of achievement:

100% Achievements: Awarded to any student that had completed a SRT, stands for "Survival Readiness Test". SRTs are like quizzes and can be taken as many times as the student has the will to learn from their mistakes. A time period of 3 days is set on each SRT to encourage students not to put this off. In many cases, agents-in-training will elect to take these at home.

Completion Achievements: Any time an agent-in-training has passed (80% or higher) for every SRT in a case file and has completed the case file analysis, that agent is awarded achievement points for keeping to the high standards of the AREA154 training.

Graffiti Achievements: An odd category of achievements that encourage students / agents to take dry erase markers and declare their chemical brilliance on a mirror or window at home by doing a designated chemistry challenge at home. They have to have photographic evidence of the mission's completion and post it to the AREA154 website.

Spec-Ops Achievements: This category of achievement is rare and often times comes with some investment. The student / agent accepts a mission that involves observation, recon, extraction, or elimination of a target in real-life. The actual danger level is way less than is sounds. These operations work a lot like "Geocaching". The localation is predetermined and students use GPS coordinates and team work to find the drops and figure out the puzzles inside.

TYPES OF ACHIEVEMENTS ARE ALWAYS EXPANDING

Q- Gadget Achievements: Anytime a case file arises or an analysis presents itself, or a current event wit in the realm of chemistry hits the press, the opportunity for the students / agents to induce some STEM power is at hand. Students identify the problem presented and then design, engineer, build a solution to the designated challenge. A solution that is not unlike the gadgets developed by Q - Division in James Bond.

Truth Achievements: As civilians, we are not always privy to the truth of any given political, social, or economic situation. Any time a student / agent can provide evidence that what we see out in the popular press isn't what we have been told achievement points are awarded. Sometimes secret documents are embedded in classified locations on the downloadable trainings. Students / agents search these documents for clues to the links where these secret declassified documents can be read and secrets of our Government are revealed.

Hands Up! Achievements: Active anticipation is critical to building capable student / agents. For each time a student raises their and contributes to the discussions at hand the student can earn up to 3 of these Hands Up! Achievements per instructional period.

Teamwork Achievements: This category of achievement is presented by nomination. At the end of a training section, each table team has the ability to nominate someone at the table who has been the example of a collaborative team player. Agents can win this over and over for as long as their team feels that they have been the best team agent they can be.

Distribution of Achievement Points: Each student / Agent has his or her own profile on the AREA 154 website that they create upon registering with AREA 154. Every time the students get access to content or SRTs they must first log into the site. The site then remembers all of the events that can lead up to being given achievements. Some achievements would be automatic, such as getting a 100% on a SRT. At which point the site automatically awards the points and the "badge" to the agent. That badge is then posted on the bottom of the site and visible to the student every time they log into the site. Some of the achievements need to be presented manually by the director of AREA 154. At which time the points are applied to their total and the achievement badge is posted to their profile.

And... Totally Customizable: Each installation of AREA154 is totally customizable by the instructors using the system. Add achievements that are specific to your school and population! The sky is the limit with the number of achievements schools could add.

RESEARCH ON AREA154 GAMEIFICATION

Feedback from the students on AREA154's Gameification element:

Since the inception of the program, simple data metrics were collected to reflect the impact of the achievement system (gameification) and how its impact on student motivation towards content mastery. AREA154: Black Ops was developed first in 2014 and was implemented for two years. In 2016 - 2019 AREA154 Apocalypse Division was build on the same operational foundation as Black Ops only more specifically gearerd towards NGSS content standards and building curriculum that would specifically address the cultural needs of the community. The Black Ops progam was run in a more affluent higher achieving community, Murrieta Mesa High School. The Apocalypse Division was implemented at San Jacinto High School in a lower achieving less affluent population.

Q: Did the AREA 154 achievement system encouraged you to want to work harder in order to advance your 'rank' within the class?

	Yes, Definitely	Occasionally	No impact
2014-2015 (BLACK OPS - MMHS, n=156)	34%	52%	14%
2015-2016 (BLACK OPS - MMHS, n=182)	28%	55%	18%
2016-2017 (APOC. DIV - SJHS, n=149)	26%	45%	29%
2017-2018 (APOC. DIV - SJHS, n=151)	31%	40%	29%
2018-2019 (APOC. DIV - SJHS, n=167)*	42%	30%	28%

Q: When you earned an achievement did you feel more successful as a student?

	Yes, Definitely	Occasionally	No impact
2014-2015 (BLACK OPS - MMHS, n=156)	85%	11%	18%
2015-2016 (BLACK OPS - MMHS, n=182)	76%	16%	8%
2016-2017 (APOC. DIV - SJHS, n=149)	71%	25%	4%
2017-2018 (APOC. DIV - SJHS, n=151)	62%	14%	24%
2018-2019 (APOC. DIV - SJHS, n=167)*	73%	18%	9%

Q: Was the possibility of earning achievement points, badges and promotions the most significant reason you pushed yourself to achieve 100% on the SRT assessments?

	Yes, Definitely	Occasionally	No impact
2014-2015 (BLACK OPS - MMHS, n=156)	81%	15%	4%
2015-2016 (BLACK OPS - MMHS, n=182)	77%	20%	3%
2016-2017 (APOC. DIV - SJHS, n=149)	72%	15%	13%
2017-2018 (APOC. DIV - SJHS, n=149)	74%	10%	16%
2018-2019 (APOC. DIV - SJHS, n=167)*	88%	10%	2%

Q: Did your participation in this achievement program influence your willingness to work harder in chemistry?

	Yes, Definitely	Occasionally	No impact
2014-2015 (BLACK OPS - MMHS, n=156)	20%	34%	46%
2015-2016 (BLACK OPS - MMHS, n=182)	24%	41%	35%
2016-2017 (APOC. DIV - SJHS, n=149)	54%	33%	13%
2017-2018 (APOC. DIV - SJHS, n=151)	57%	27%	16%
2018-2019 (APOC. DIV - SJHS, n=167)*	61%	28%	11%

** During this year an more attention was put into expanding achievments,attention to the learder board, and student recognition for their promotions and achievments.*

STUDENT FEEDBACK ANALYSIS & RESULTS

Summarization of the feedback:

Though the analysis of the achievement system was not exhaustive, several trends can be extracted from the data:

- The students tend to put more effort into attaining the 100% score necessary to attain the achievement points.
- The achievement system had an impact on the majority of the classes to work harder either an occasional or more regular bases to demonstrate skill mastery.
- The achievement points played an influential role in the students' decision to retake quizzes to get 100%.
- Students who are normally considered 'high achievers' participate in the gameification more frequently, however, students who tend not to classify themselves as 'good at school' benefitted the most from the achievements and the leaderboad - *(This observation comes is both connected to the quantitative results of the survey and observational experience over 5 years of implementation.)*
- Supported by both quantitative results and anecdotal observations, the achievements provided a notable sense of achievement in both groups that were high-achieveing and low-achieving.

Additional insights after having implemented this system over the course of an academic year. These are observations of student behavior in association with the achievement system.

- **Students require immediate feedback for the achievement system to have it's maximum effect.** Towards the middle to the end of the second semester the achievements were not immediately connected to the SRTs and students didn't receive their points immediately after the necessary score had been achieved. This caused students to not feel the sense of satisfaction of the achievement. The number of achievements reached by students during this time dropped substantially.
- **The icon list on the students profile page has an impact on the sense of achievement and motivation associated with this system.** In the occasions when the icon was not placed on the students' profile pages, the students would complain about the icon not being located on their profile and insist that it be corrected as soon as possible. When these problems were not addressed with in a relatively short period of time, the number of students that tried to reach the NEXT achievement dropped.
- **The type 'A' achiever students and students that had a history with video game type achievements benefited more from the achievement system than most of the other types of students.** After an analysis of the leaderboard, the students on the to 50 fit this profile of being achievement oriented in school to begin with, or achievement oriented from a video game perspective. Students that were neither gamers or scholastic achiever types did not benefit as much from the achievement system. Though, when asked, these students still enjoyed the fact that they had achievements posted on their profile. They we simply not motivated by the achievement prior to having acquired it.
- **The amount of effort and importance the instructor put into the leader board and the achievements directly affected the influence the gameification had on the students.** If the teacher thought it was important and provided even passing attention to student ranks, achievements, or bragged upon students in other classes who recently acquired achievements experienced higher levels of student in engagement than those who did paid little attention to the system.

APPENDIX B

AREA154: Apocalypse Division HyperDoc PDFs

AREA 154 :APOCALYPSE

ADVANCED RESEARCH & EVIDENCE ANALYSIS: CHEMISTRY DIVISION

CASE FILE:
[AS:01] CALDERA

Achievement Points: Experimental Motivation System
Designed and built by: Torrence Temple

Summary: All of the curriculum is delivered to the student in the form of an interactive PDF. The next pages exemplify the PDF user interface and explain the iconography of the documents. In addition, comments made "from the director" are tips and lessons learned about implementing the content.

Video walk throughs are also available upon request.

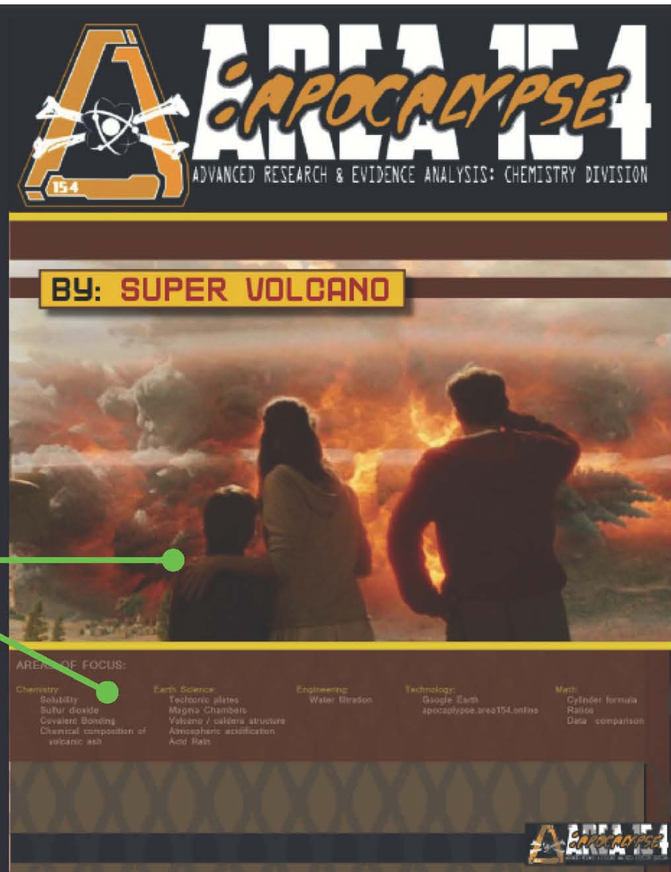
Following the visual walkthrough is an example a suggested implementation time line for the Fall semester, thought implementation timelines can vary greatly among different instructors.

The Examulation - an assessment like no other.

APOCALYPSE BY CALDERA : CASE FILE ORIENTATION

CASE FILE COVER

Cover art from ***2012,*** the movie.



THE IMAGE

This scene takes place as the protagonists (the good guys) land in Yellowstone National Park realizing that the kooky conspiracy guy was dead on with his prediction about the caldera on the brink of exploding. The super volcano exploded in fantastic glory. This is a frame from that scene. As spectacular as this is, the explosion is still not big enough.

THE CONTENT

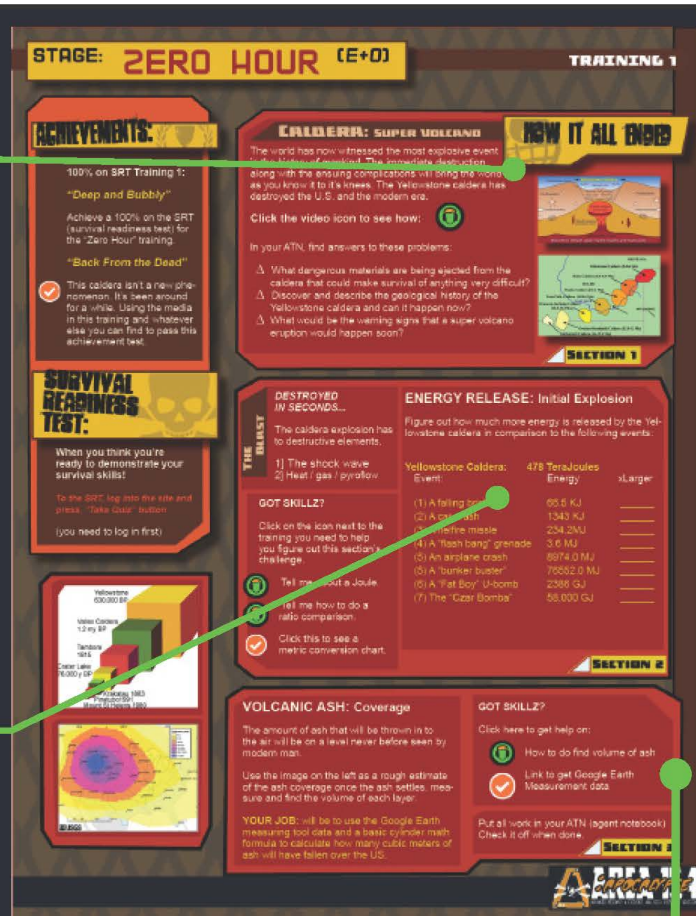
This area of the cover page is dedicated to show the chemistry and STEM content addressed in this scenario.

NOTES:

APOCALYPSE BY CALDERA : CASE FILE ORIENTATION

TRAINING ONE

THREE [3] SECTIONS



SECTION 1:

TIME LINE: 1 CLASS PERIOD
This section includes a 24 minute video on the technical aspects of the Yellowstone Caldera. In addition to completing the questions (∆) are next to questions most students will complete this area at or near the end of the period.

Suggestion: Finish watching the video if agents have not yet done so.

From the director...
Watch for connectivity issues with YouTube. For now it's linked there. If lots of agents have Chromebook issues, perhaps show the video as a class.

HOTSPOTS

SECTION 2:

TIME LINE: 1-2 CLASS PERIODS
Students will be comparing the energy output of events they might be familiar with to the energy released in a caldera eruption Agents will be doing a ratio comparison, but have to ensure all the units are the same first. Support videos are listed on the side.

Suggestion: Perhaps use the iPad and the AppleTV to do an example on the front screen. Go slow. Use small steps.

From the director...
The videos connection to YouTube for now. Consider class views for internet connection issues. Agents will struggle with the math and metric unit conversion.

HOTSPOTS

SECTION 3:

TIME LINE: 1-2 CLASS PERIODS
The calculations here request the agent to make a calculation that sums all of the layers of volcanic ash. The thickness of the area is given and the area data is provided by accessing the link provided. The goal is to continue to establish shock and awe of the super volcano. Ask agents what they think the volume of erupted ash might be. Perhaps write predictions on the front screen with the iPad.

From the director...
In the past students when allowed to tackle the math on their own... struuuuuglllled. I've noticed that any applied math that takes more than two steps loses most students. Working with the agents in stages might work better. Explain one step. Let them work. Check on them, then move to the next step.

HOTSPOTS

APOCALYPSE BY CALDERA : CASE FILE ORIENTATION

TRAINING TWO

THREE [3] SECTIONS

SECTION 1:

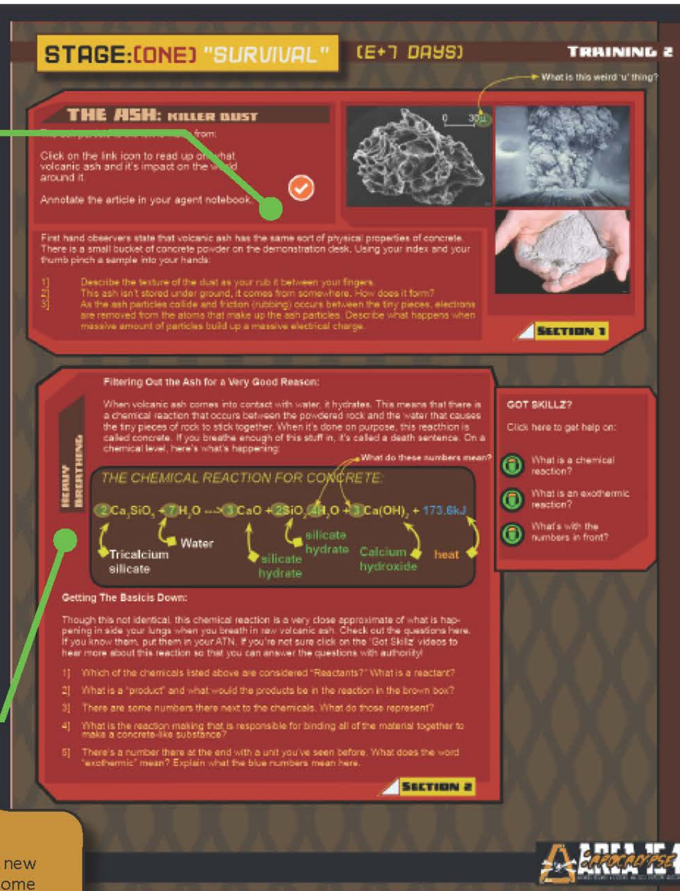
TIME LINE: 0.4 CLASS PERIODS
Volcanic ash is the focus here. The link here goes to an off-site page that presents the structure, features, and dangers of the volcanic ash. The directives are in the box below along with the focus areas agents should answer in their notebooks.

ESTABLISHING HABITS: Insist on full sentence answers!

MATERIALS: Dry concrete powder for agents to put hands in and feel.

From the director...
Agents will use "it" to describe key terms that they should be getting familiar with. NEVER USE 'IT'! Any agent with 'it'-syndrome should be sent back to their seat to fix it.

HOTSPOTS



STAGE:(ONE) "SURVIVAL" (E+7 DAYS) TRAINING 2

What is this weird 'u' thing?

THE ASH: KILLER DUST

from:

Click on the link icon to read up on what volcanic ash and it's impact on the world around it

Annotate the article in your agent notebook.

First hand observers state that volcanic ash has the same sort of physical properties of concrete. There is a small bucket of concrete powder on the demonstration desk. Using your index and your thumb pinch a sample into your hands:

1] Describe the texture of the dust as your rub it between your fingers.
2] This ash isn't stored under ground, it comes from somewhere. How does it form?
3] As the ash particles collide and friction (rubbing) occurs between the tiny pieces, electrons are removed from the atoms that make up the ash particles. Describe what happens when massive amount of particles build up a massive electrical charge.

SECTION 1

HEAVY BREATHING

Filtering Out the Ash for a Very Good Reason:

When volcanic ash comes into contact with water, it hydrates. This means that there is a chemical reaction that occurs between the powdered rock and the water that causes the tiny pieces of rock to stick together. When it's done on purpose, this reacthion is called concrete. If you breathe enough of this stuff in, it's called a death sentence. On a chemical level, here's what's happening:

What do these numbers mean?

THE CHEMICAL REACTION FOR CONCRETE:

$2Ca_3SiO_5 + 7H_2O \dashrightarrow 3CaO + 2SiO_2 4H_2O + 3Ca(OH)_2 + 173.6kJ$

Tricalcium silicate, Water, silicate hydrate, silicate hydrate, Calcium hydroxide, heat

GOT SKILLZ?

Click here to get help on:

What is a chemical reaction?

What is an exothermic reaction?

What's with the numbers in front?

Getting The Basicis Down:

Though this not identical, this chemical reaction is a very close approximate of what is happening in side your lungs when you breath in raw volcanic ash. Check out the questions here. If you know them, put them in your ATN. If you're not sure click on the 'Got Skillz' videos to hear more about this reaction so that you can answer the questions with authority!

1] Which of the chemicals listed above are considered "Reactants?" What is a reactant?
2] What is a "product" and what would the products be in the reaction in the brown box?
3] There are some numbers there next to the chemicals. What do those represent?
4] What is the reaction making that is responsible for binding all of the material together to make a concrete-like substance?
5] There's a number there at the end with a unit you've seen before. What does the word "exothermic" mean? Explain what the blue numbers mean here.

SECTION 2

SECTION 2:

TIME LINE: 0.5 - 0.75 CLASS PERIODS
The exposure to the reaction equation will be a new experience for most of the agents. As a result, some time is spent breaking down this reaction equation of concrete and water. This reaction is very similar to the reaction that volcanic ash has with the water in a person's lungs when ash is inhaled.

VIDEOS: The reaction equation is explained in sections using the videos. The area to the right has the links to those videos. While the videos are short and sweet and to the point, some direct instruction might be beneficial.

From the director...
This construct is not an each thing for students to immediately grasp. Perhaps an analogy of a chemical reaction equation is a lot like a sentence. The reactants side would be like the subject, the arrow the verb, the products would be the predicate. Coefficients act like modifiers or adjectives

HOTSPOTS

HEADS UP...

SIGNATURES / STAMPS
You might be signing Agent Training Notebooks. Either works, just be mindful that each agent should have FIVE (5) of these stamps or signatures.

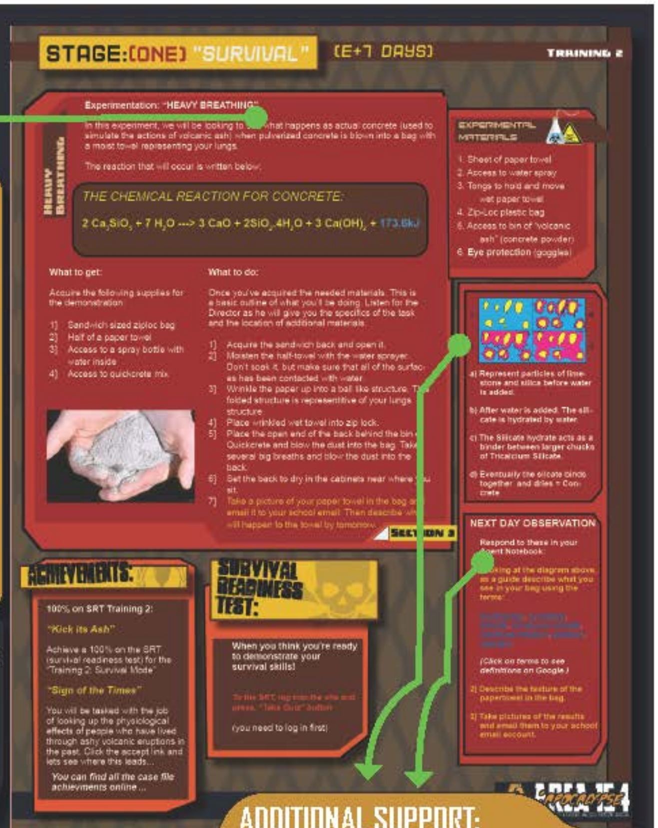
If you, the director, have not stopped and offered time for students to get their books stamped or signed, this would be a great time to do it.

Encourage the students to not fall behind. Most agents are NOT used to being giving this type of freedom and pacing. They will slack.

APOCALYPSE BY CALDERA : CASE FILE ORIENTATION

TRAINING TWO

THREE [3] SECTIONS (CONT.)



SECTION 3:

TIME LINE: 2.0 CLASS PERIODS

HANDS-ON: Analysis and observation of the effects of volcanic ash on the lungs. Simulating the lungs would be wet paper towels or school toilet paper (because it's really strong).

MATERIALS:
concrete, paper towels, water sprayer (hand bottle), Ziploc sandwich bags.

BASIC INSTRUCTIONS:
Agents can access the instructional parts of the experience in the upper right hand corner of the training.

PHASE 1: In stages, groups take their towel, wet it, and expose it to the concrete.
PHASE 2: In an open Ziploc bag, set aside to dry for as long as it takes to dry. Students observe each day.

AGENT OUTPUT: Setup seven (7) asks the agent to take a picture of the final dried lung sample. The picture acts as the basis for their conclusions paragraph.

From the director...

The exposure phase (1), will take about 0.75 of a class period if the verbal explanations are included in the timing. If students finish early or are waiting for their turn, encourage agents to go ensure all previous sections are done.

Drying should take 2-3 days depending on classroom ventilation.

HOTSPOTS

HEADS UP...

SRT TIME!

Getting agents to take the assessments on their own is an exercise in futility. In the past, the use of a 15 min challenge to get ALL of the agents to at least take the Training SRT once.

USING THE COMPUTER AS A TIMER:
Click on this link (http://www.online-stopwatch.com/countdown/)

USE THE IPAD:
Go to the "Clock" App and set the timer for 15 min and project the timer through the AppleTV for all students to see.

ENGAGEMENT TRICKS:
Use small prices (like a candy drawer) or perhaps a Google doc that keeps track of the number of 100% each period. Contest, baby!

ADDITIONAL SUPPORT:

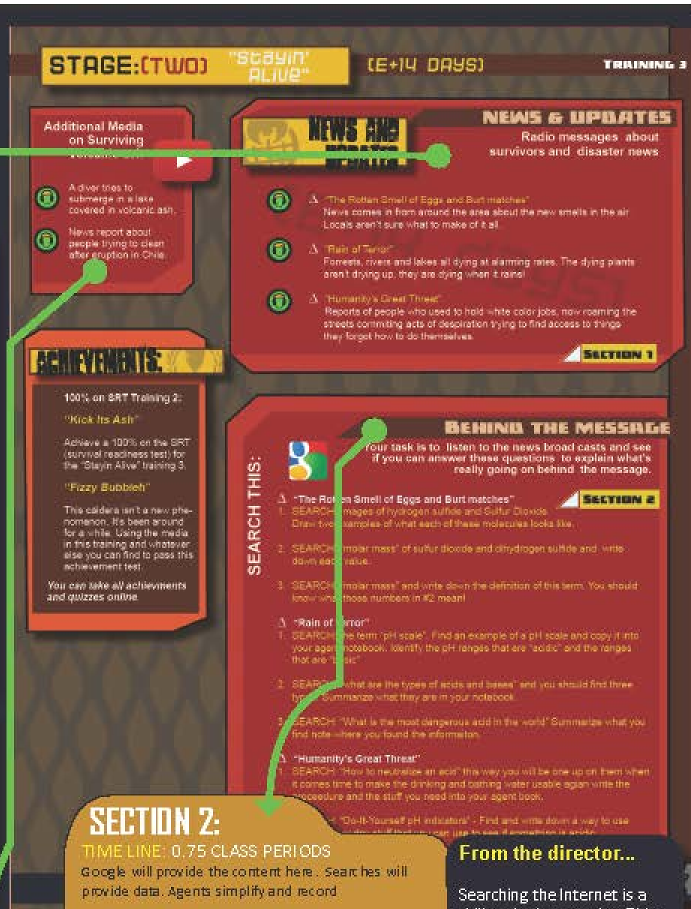
CONCRETE FORMATION: This graphic can be used by students to answer questions from the hands-on experience. The availability of a video for this process might be a great media element to have, though locating one might prove to be problematic. Special prize for the Director that can find one!

TERMINOLOGY SUPPORT:
This content zone encourages the use of experience terminology in their answers. Definitions for these terms are linked here for students to have access to information defining the terms and providing additional sources to encode the meanings.

APOCALYPSE BY CALDERA : CASE FILE ORIENTATION

TRAINING THREE

FOUR [4] SECTIONS



SECTION 1:

TIME LINE: 0.3 CLASS PERIODS

HUMAN EXPERIENCE: These three pieces of media are audio files taken from a radio show. The audio clips portray radio personalities reacting to the caldera eruption days weeks afterward.

AGENT RESPONSE:
Listen to the audio file then write a 2-3 sentence response elaborating on what the would feel if they were listing to the radio and heard these clips.

WHAT IS THE PURPOSE OF THIS METHOD?
The design methodology in AREA154 is founded on the use of psychological and emotional arousal. The content is buried into these pieces of audio. From time to time the curriculum or the Director should revisit the catastrophic circumstances under which the agents are being trained.

OPTIONS: Keep your eyes on sites that monitor the swelling activity of the Yellowstone Caldera. Any time the park goes through a swelling cycle. Post it. That will get agents' attention!

From the director...
In the past, agents have listened to the audio clips and then asked, "Now what do I do." In future versions of this section students will receive more specific directions on specifically what and how much to write.

Focusing on the emotional impact of the after effects of the eruption helps drive engagement.

HOTSPOTS

ADDITIONAL SUPPORT:

CONCRETE FORMATION: These videos are additional to the curriculum and are provided for extension and class discussion. None of the material in these videos appear on any assessments. Agents curious about the caldera and its impact will access these videos.

SECTION 2:

TIME LINE: 0.75 CLASS PERIODS

Google will provide the content here. Searches will provide data. Agents simplify and record

SCIENCE FOCUS: Discuss the content of the radio messages after a set time period (15 min or so) to flush out key details.

KEY SEARCH WORDS: Agents should use terms they heard and words in the questions to guide their search to find missing information.

Provide examples of how to translate content in the messages into scientific facts about the situation.

"Rotten egg smell"
Means $SO_2(g)$ being ejected into the air

Demonstrate how an agent can pose a question to Google to get this information.

From the director...

Searching the Internet is a skill and takes practice. This activity might go smoother if the Director places examples of search techniques on the AppleTV with the iPad or to place some instruction of this process on the front screen.

Or perhaps show this video on how to search stuff on Google to ensure you get the information agents need.

Click here for video:

HOTSPOTS

APOCALYPSE BY CALDERA : CASE FILE ORIENTATION

TRAINING THREE

FOUR [4] SECTIONS (CONT.)

SECTION 3:

TIME LINE: 0.3 CLASS PERIODS

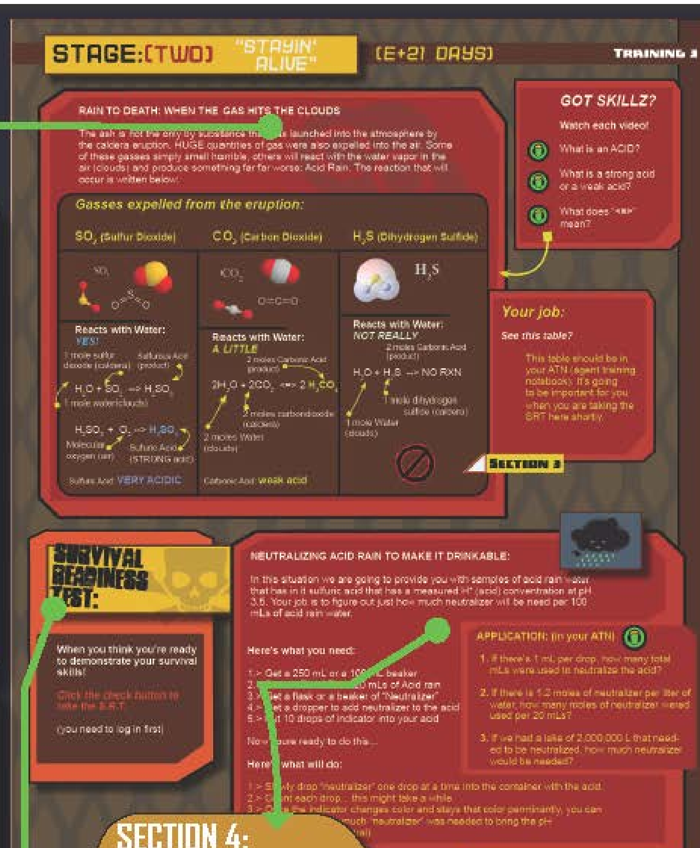
VISUALLY REPRESENT THE CHEMISTRY: The graphic in the brown region visually presents what happens to the gasses when exposed to water in the atmosphere.

AGENT RESPONSE:
It's suggested that the students take some time and record this chart into their ATN. The process is a little time laden, but gives each student the opportunity to slowly process a complex subject matter. This chart is what the Director will sign off or stamp.

WHAT IS THE PURPOSE OF THIS METHOD?
Chemistry is, arguably, the most difficult science to grasp for high school students. Traditionally students don't even see a reaction equation until well into the second semester. The reaction equation is a recurring focus across almost all of the apocalypse scenarios. Exposure and changes of context lowers the anxiety associated with the symbolism and formatting used in chemical communication of reaction systems.

From the director...
If rulers are not provided to use to make this chart, the results are very sloppy. Also, indicate that the chart should be about 1/3 to 1/2 of the page before they start drawing. Agents might also ask, "Can I just print this out?" No, and here's why. The process of using small motor muscle systems along with visual support, the research states, encodes information longer when written by hand.

HOTSPOTS



HEADS UP...

SRT TIME

Getting agents to take the assessments on their own is an exercise in futility. In the past, the use of a 15 min challenge to get ALL of the agents to at least take the Training SRT once.

USE COMPUTER OR IPAD AS A TIMER:
Click on this link (http://www.online-stopwatch.com/countdown/)

COMPETITION:
100% count! Candy and competitions are have been solid leverage for focusing wayward students.!

SECTION 4:

TIME LINE: 2 CLASS PERIODS

HANDS-ON: Analysis of neutralization of acidified water using red cabbage as an indicator.

MATERIALS:
Acid solutions (Carbonic acid, Sulfuric acid) sectioned out into small 150 ml beakers. One acid beaker per table is good.
Indicator solution: Use "Ninja" blender to chop up red cabbage with water. The purple solution extracted from the mix is the indicator.
Eye droppers: Used for standardization and then for the neutralization.

BASIC INSTRUCTIONS:
Standardize the volume delivery with a 0.25 M HCl Solution, then titrate unknown by counting drops.

From the director...

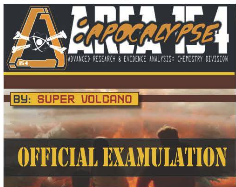
Go in stages. Take time to do just the standardization of the dropper volume. OR do it ahead of time and have it ready for the students.

Counting drops is pretty easy but doing the math to figure out how much acid was added. Perhaps use this as an advanced or achievement worthy topic.

The neutralization point sneaks up fast. If they pass it they MUST start over. The first few will be unthrilled!

HOTSPOTS

SUMMATIVE: THE "EXAMULATION"



THERE'S NO TEST LIKE IT.
Part exam and part simulation, the summative assessment for each of the 5 apocalypse level challenges puts students into the exact event they have been training for. The assessment begins, like any story would, at the begining. The exam itself reads like a story. Videos support the simulation and add contect to the questions. The questions are then answered on the AREA154 website.

VARIOUS INPUT

VIDEO SUPPORT

Click the video icons to watch videos that support the simulation and assist in answering questions.

GRAPHS & CHARTS

Students access charts and graphs that are directly connected to the storyline. Results actually help drive the story element of the simulation.

VARIOUS OUTPUT

NARRATIVE EXPLANATIONS

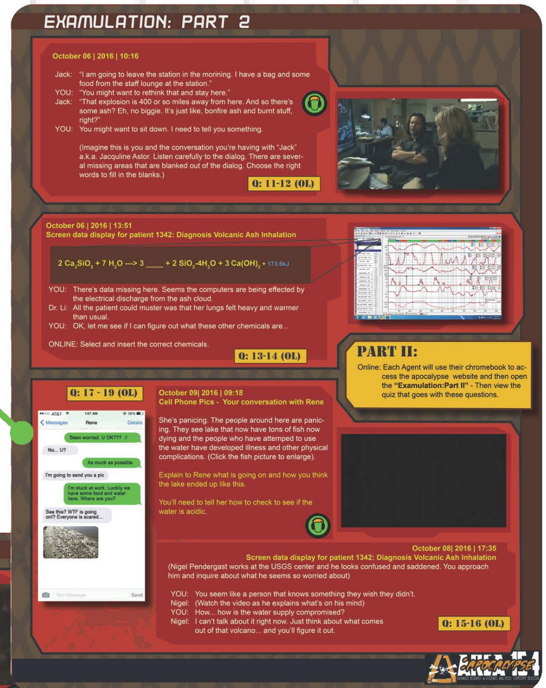
Questions addressing larger more important content standards require the ***student to write their answers out in full sentences on the website***. This provides the teacher a better understanding of the students thinking and preperation.

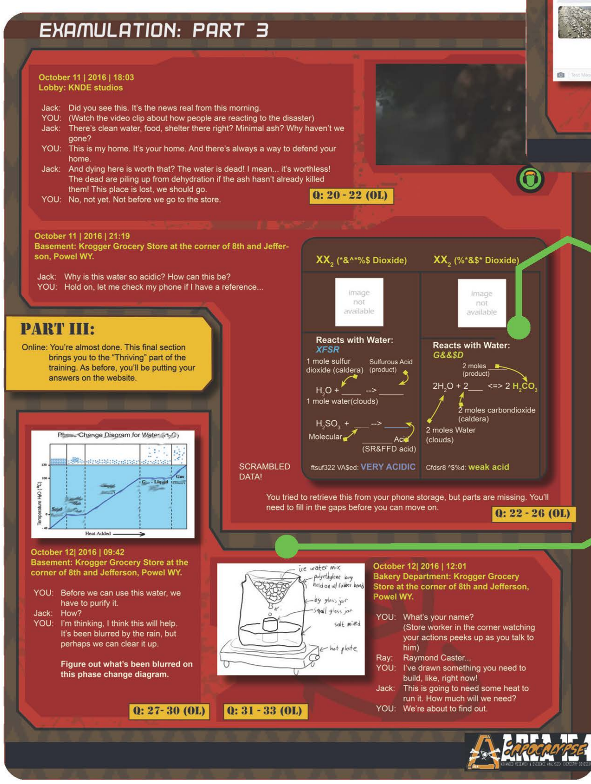
SUMMATIVE: THE "EXAMULATION"

RELATIONAL INPUT

QUESTIONS PLAY ON SOCIAL MEDIA

The examulation plays upon the rampancy of social media and includes it into the assessment process. In part 2 the ***students explain in narrative*** about the reason for the dead fish in the picture that was texted. All the questions within the examulation are contextualized and part of the simulation story line.





STEM ASSESSMENT

STEM REVSITED

The hands-on STEM activities also play a role in the simulation. Students are provided incomplete data that was presented to them during their trainings and applied in this simulated event.

AREA154: APOCALYPSE DIVISION FALL TIMELINE

FALL SEMESTER

AT A CONSERVATIVE PACE:

The diagram to the right presents a general timeline for the first semester. The speed by which the students pass through the curriculum largely depends on at-home time alotted to finishing the training sections.

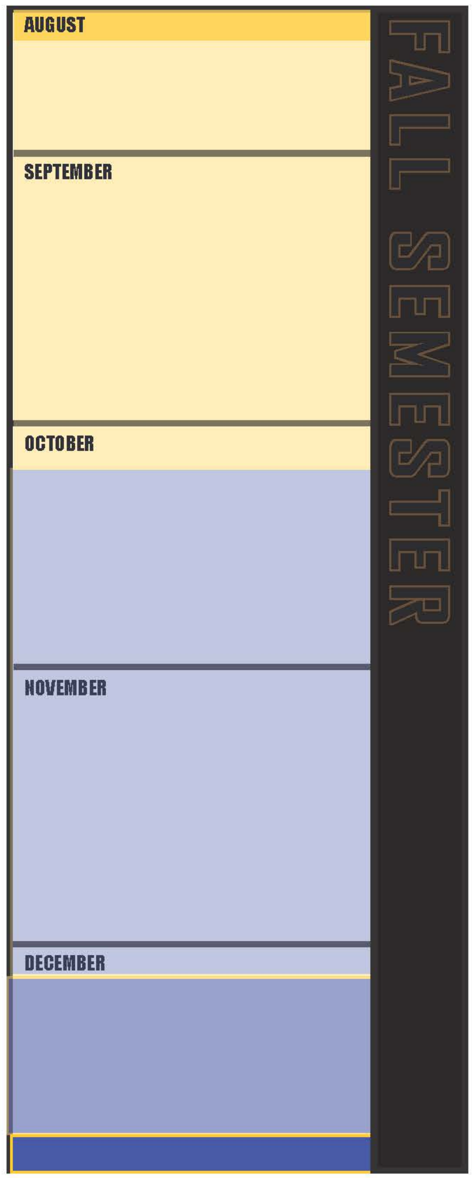
The pattern here represnts a timeline where little or no support was provided to the students and most of the trainings were completed during class.

INTRODUCTION WEEK

CALDERA

ZOMBIE APOCALYPSE

FINALS WEEK



From the director...

The AREA154: Apocalypse Division curriculum has been refined over the last three years in live classroom settings. The times suggested here will vary depending upon the pace the teacher feels is productive.

Please note thought... There's no real "correct" order for the casefiles.

Each one of the AREA154 apocalyptic scenarios are stand-alone NGSS STEM designed unites of learning. Everything needed to learn the material is contained within the unit. Some topics are revisited in several of the case files such as the use of reaction equations and density. Our research has demonstrated that these topics require several reinforcement opportunities.

That being said, it is suggested that the "Economic Collapse" unit be done at the end of the year. The last part of the case file involves building pressurized water rockets and would benefit student focus to be done near the endf of the academic year (May - June).

HOTSPOTS

APPENDIX C

IRB Subject Recruit Documentation

BOISE STATE UNIVERSITY

INFORMED CONSENT

Study Title: Theories connecting Hispanic STEM students and perceived success through applied ubiquitous learning technologies.

Principal Investigator/Faculty Adviser: Dr. Young Baek

Co-Principal Investigator: Tory Temple, Doctoral Student

Sponsor: Boise State University, Department of Education

Dear Parent/Guardian:

My name is Tory Temple and I am a doctoral student in the educational technology program at Boise State University. I am asking for your permission to include your child in my research. This consent form will give you the information you will need to understand why this study is being done and why your child is being invited to participate. It will also describe what your child will need to do to participate as well as any known risks, inconveniences or discomforts that your child could encounter while participating. I encourage you to ask questions at any time. If you decide to allow your child to participate, you will be asked to sign this form and it will be a record of your agreement to participate. You will be given a copy of this form to keep.

➢ PURPOSE AND BACKGROUND

This research study attempts to learn more about how the use of an educational instruction paradigm referred to as “ubiquitous learning” effects how Hispanic students demonstrate engagement, perception of knowledge, and their perceptions of the quality of their learning experiences in a STEM oriented chemistry class at San Jacinto High School. Th project maintains the theory that uLearning provides unique access to learning that could benefit and promote successful STEM learning experiences. This study is designed to investigate how uLearning technologies might assist in building the sense of self-confidence in science, technology and math related subjects.

➢ PROCEDURES: INTERVIEW

If you agree to be in the study, you will be asked to participate in two brief interviews: one at the beginning and one at the end of the semester. Each interview will last approximately twenty to twenty-five minutes. During this time you will be asked to answer questions based on your experiences with the uLearning technology and design properties. The interview will take place a time that is convenient for you (participant) and will be conducted on Zoom (or similar platform). Please note that the sessions will be recorded. The audio and video will be recorded for data collection purposes. As some of the questions are complex, all modes of communication are encouraged, including facial expressions, hand movements, and other types of non-verbal communication. The questions will be delivered to you in a conversational format. Some questions may require some follow-up questions to help acquire a better understanding of the participants experiences with the AREA154: Apocalypse Division STEM curriculum (The uLearning technology under study).

- **RISKS/DISCOMFORTS**

It is possible, however unlikely, your child may be uncomfortable being recorded on video through the Zoom application. Each participant is being asked to conduct the interview with the camera on. The video of the interviewee (your child) provides non-verbal feedback in a manner that may be critical to understanding the students experiences while participating in the AREA154 Apocalypse Division program (the uLearning system under study). High school students are apt to use their hands and be visually very expressive and that data can help communicate where words cannot. You can ask for your child not to be taped at any time. Your child may also ask not to be taped at any time. We may continue with the interview if you and your child are willing. You are able to remove your child from the study at any time and for any reason.

- **EXTENT OF CONFIDENTIALITY**

Reasonable efforts will be made to keep the personal information in the research record private and confidential. Any identifiable information obtained in connection with this study will remain confidential and will be disclosed only with your permission or as required by law. The members of the research team and the Boise State University Office of Research Compliance (ORC) may access the data. The ORC monitors research studies to protect the rights and welfare of research participants.

Your child's name will not be used in any written reports or publications which result from this research, Data will be kept for three years (per federal regulations) after the study is complete and then destroyed.

- **EXTENT OF CONFIDENTIALITY**

Reasonable efforts will be made to keep the personal information in your research record private and confidential. Any identifiable information obtained in connection with this study will remain confidential and will be disclosed only with your permission or as required by law. The members of the research team and the Boise State University Office of Research Compliance (ORC) may access the data. The ORC monitors research studies to protect the rights and welfare of research participants.

- **PAYMENT**

There will be no payment to you or your child as a result of your child taking part in this study. They will however be offered some compensation for their time in the form of three (3) signed community service hours for their voluntary contributions to the study.

- **QUESTIONS CONCERNING THE RESEARCH PROCESS**

If you have any questions or concerns about your participation in this study, you should first contact the principal investigator, Dr. Young Baek, at youngkyunbaek@boisestate.edu or the co-principal investigator, Tory Temple, at torytemple@u.boisestate.edu or (951) 973-4141.

If you have questions about your rights as a research participant, you may contact the Boise State University Institutional Review Board (IRB), which is concerned with the protection of volunteers in research projects. You may reach the board office between 8:00 AM and 5:00 PM, Monday through Friday, by calling (208) 426-5401 or by writing: Institutional Review Board, Office of Research Compliance, Boise State University, 1910 University Dr., Boise, ID 83725-1138.

DOCUMENTATION OF CONSENT
I have read this form and decided that my child will participate in the project described above. Its general purposes, the particulars of involvement and possible risks have been explained to my satisfaction. I will discuss this research study with my child and explain the procedures that will take place. I understand I can withdraw my child at any time.

____
Printed Name of Child

____________________________ ____________________________________
Printed Name of Parent/Guardian **Signature** of Parent/Guardian Date

____ __________
Signature of Person Obtaining Consent Date

BOISE STATE UNIVERSITY

INFORMED CONSENT

Study Title: Theories connecting ubiquitous learning technologies and Hispanic STEM students.

Principal Investigator: Torrence Temple **Co-Investigator:** Dr. Young Baek

Sponsor: Boise State University

Greetings once again. As you know, I was your chemistry teacher during the 2019-2020 school year and was responsible for the prototype learning tool called *AREA154: Apocalypse Division*. This unique design of this program has produced some interesting results that will be the focus on my doctoral research. My intention here is simple. I would like you to participate by being interviewed about your experiences as an student (or agent) within the program.

I encourage you to ask questions at any time and to talk to your parents about participating. If you decide to participate, you will be asked to sign this form and it will be a record of your agreement to participate. You will be given a copy of this form to keep.

➢ PURPOSE AND BACKGROUND

As a part of the dissertation process, extensive topical background research has to be done about the research focus. The background research revealed vast amounts of government data, and studies suggested that Hispanic students are falling behind academically. Additionally, they have the highest high school dropout rate of any significant minority group. Moreover, Hispanic students also demonstrated a surprising lack of confidence relating to their abilities to be successful in STEM-related subjects. I had witnessed this through decades of professional experience, but the research confirmed it. The question now was, "What can be done about it?" That is where the AREA154 project comes into play. The AREA154 program is centrally located and accessible from any device anywhere on Earth with an internet connection. Additionally, the learning content is available 24 hours a day. This combination of factors appears to be making an impact on that achievement gap. These observations concerning AREA154 were only that, general anecdotal data collection. However, it laid the groundwork for this study to identify the uLearning characteristics that were most responsible for the changes, and what did these changes ultimately mean for the students?

➢ PROCEDURES

The data collection procedures are straightforward and completed in just a couple of steps:

1. Watch a video prepared for them and intended to remind them of the environment, tools, events, curriculum, and other experiences related to their time within the uLearninig environment. Memory-refreshing material would include images of notebooks (names removed), screenshots of web-interfaces, class videos, and other instructional media. The goal would be to help them recall more of their experiences from a year or more ago. The video would likely not be longer than 10 minutes.

2. Participate in a recorded online interview/discussion where they discuss their experiences related to the uLearning system under investigation. The interview process would likely not last longer than 20 minutes. The interviewer may ask to follow up with additional questions that do not appear in the original question list. These questions would only act to clarify information provided by the participant during the initial interview. The participant has the right to choose not to answer if they wish. If a post-interview was needed, it would occur a week or two would likely occur after the initial interview and not last more than a few minutes over a zoom conversation.

- **RISKS/DISCOMFORTS**

There might have been a time where being on a Zoom conference call might have seemed awkward. Perhaps not so much anymore. There is no risk to your grade, as all of that is in the past. So speaking your mind about the *AREA154: Apocalypse Division program* will have ZERO impact on your grades. However, some discomfort might be experienced if you have to tell me critical things about a program I invested so heavily in the making. Rest assured, critical well-thought-out input is EXACTLY what I am looking for in this study. Critical feedback could mean specific elements played a mostly positive role for you – and that's good! Critical feedback can also mean identifying aspects of the program that, if addressed, could make the program even more useful. THAT is my goal. Research the impact the system had, see how your experiences affected you, and investigate possibilities for an even better experience.

- **EXTENT OF CONFIDENTIALITY**

The research procedure ensures reasonable efforts to keep the personal information in your research record private and confidential. Any identifiable information obtained in connection with this study will remain confidential and disclosed only with your permission, or as required by law, the members of the research team and the Boise State University Office of Research Compliance (ORC) may access the data. The ORC monitors research studies to protect the rights and welfare of research participants.

Your name will not be used in any written reports or publications which result from this research. Data will be kept for three years (per federal regulations) after the study is complete and destroyed.

BENEFITS / PAYMENT

As you know, there is a graduation requirement for Community Service Hours (CSH). As a perk for participating in the study, you will earn three (3) community service hours upon successfully completing the interview. Other than the allocation of CSH, there will be no official payment for your participation.

➢ QUESTIONS

If you have any questions or concerns about your participation in this study, you should first contact the principal investigator, Dr. Young Baek, at youngkyunbaek@boisestate.edu or the co-principal investigator, Tory Temple, at torytemple@u.boisestate.edu or (951) 973-4141.

If you have questions about your rights as a research participant, you may contact the Boise State University Institutional Review Board (IRB), which is concerned with the protection of volunteers in research projects. You may reach the board office between 8:00 AM and 5:00 PM, Monday through Friday, by calling (208) 426-5401 or by writing: Institutional Review Board, Office of Research Compliance, Boise State University, 1910 University Dr., Boise, ID 83725-1138.

DOCUMENTATION OF CONSENT

I have read this form and decided that I will participate in the project described above. Its general purposes, the particulars of involvement, and possible risks have been explained to my satisfaction. I understand I can withdraw at any time. I have received a copy of this form.

I understand that I can choose not to participate in this study or to withdraw from participating at any time with no adverse effect.

Printed Name of Study Participant | **Signature** of Study Participant | Date

Signature of Person Obtaining Consent | Date

Data Collection Acknowledgement

Courtney Hall (Principal, SJHS)

chall@sanjacinto.k12.ca.us

10/9/2020

Dear Torrence Temple,

Based on my review of your proposed research, I permit you to conduct the study entitled Theories pertaining to the application of uLearning technology and Hispanic STEM students' engagement behaviors within the San Jacinto High School. As part of this study, I authorize you to conduct recruitment through district allotted resources, contact parents, and conduct data collection procedures at this facility. Individuals' participation will be voluntary and at their discretion.

We understand that our organization's responsibilities include:

Use of district-provided communication tools and acquire participants and conduct data collection interviews with students provided parental consent was obtained before the data collection procedures. Data collection may include using former students' Aeries database information as long as student ID is kept confidential. We reserve the right to withdraw from the study at any time if our circumstances change.

The research will include the use of San Jacinto's licensed Zoom communication tool and district email services procured through Google. We understand that the Interviews will take place online (not on campus), will be recorded, and stored for analysis at a later date on secured servers located at Boise State University. This authorization covers the span of the Fall 2020-2021 school year (August – mid-December 2020.) The possibility of a time extension can be if deemed necessary for the completion of the research.

I confirm that I am authorized to approve research in this setting.

I understand that the data collected will remain entirely confidential and may not be provided to anyone outside the research team without permission from the Boise State University IRB.

Sincerely,

Courtney Hall

Principal
San Jacinto High School

Sample recruitment email for potential participants

Greetings Agent, I could use your help.

As Agents of AREA154, you have experienced a unique opportunity to experience NGSS chemistry taught in a very different way. This makes your experience valuable and I'm here to ask if you would consider being a part of a study that wants to learn more about your experiences in the program.

As may recall, I am in the dissertation phase of my doctoral work at Boise State University. I am looking for about 15 – 20 students that might be willing to provide some of their time to be interviewed about their experiences with the *AREA154: Apocalypse Division* program. I have hand selected students to reach out to because they meet specific criteria that is important to the study, and YOU were selected.

Here are some basic details about the interview process:

- The **interview would be held on the SJUSD's Zoom platform** and would be held a time to be scheduled by you.
- **Two days prior to the interview you will be specifically briefed** on what the my research is about, your role in the interview process, and you will watch a 10 minute (approx.) video that will walk you through visual images that are designed to take you back to your AREA154 experiences. A long time has passed between then and now, the video will help you recall some those experiences.
- **The interview will be video screen-recorded** and, ideally, your camera would be on as well. People communicate physically with their hands and facial expressions, and all of that data is important for the research.
- **I (Mr. Temple) will be conducting the interview** via audio only and it will be very casual and conversational. I may ask some follow up questions to make sure I understand the true nature of your message.
- **Once your done, you will receive 3 hours of community service!** All you need to do form to me and I will sign it for you.

Permissions:

If you are interested, that would be great! I will also need your parents (or whoever is legal in charge of you) to also sign off to provide permission. As soon as you reply to this email that you would like to participate, I will send you the form that you and your legal guardians will need to sign. Once that's done, we will set up a time online to meet. Two days before the interview I'll send you a copy of the questions so you can think about your answers along with the preview "reminder" video.

If you have any questions, please email me at torytemple@u.boisestate.edu or text me at (951) 973-4141.

Thank you for your help!

Mr.Temple

Sample verbal consent – via Zoom if parent did not sign form for student permission

[Pre-screen-recording briefing]

My name is Tory Temple, Mr. Temple, and I was not only your student's chemistry teacher in the past, but I am also a doctoral student at Boise State University. I am conducting some research that would require your permission for your son (daughter) to participate. But first, let me tell you a little about the research.

They participated in a very unique, specifically designed curriculum when they were with me as my students. They have been chosen based on a selection criterion that best fits the type of students the curriculum was designed to reach. All your students need to do is to answer the interview questions about their experiences while in the program.

As your son (daughter) is under the age of 18, I would like to ask for your permission for them to participate in the study. They have already consented to participate, however, I would also like to attain yours as the legal guardian. If you would like to give that permission, that would be great. All I will need to do is begin a short screen recording with your face in the video. I will read a small script, and you will replay when asked to provide your information.

Do you have any questions for me? If at any time later you have questions or concerns about your participation in this study, you should first contact the principal investigator, Dr. Young Baek, at youngkyunbaek@boisestate.edu or the co-principal investigator, Tory Temple, at torytemple@u.boisestate.edu or (951) 973-4141.

[Start screen recording]

My name Mr. Temple and I am conducting qualitative research interviews that include (name of student). I am seeking your permission for them to participate in the project. Know that you or your child can quit the interview at any time or may opt to skip questions if any questions are ones that you would wish not to answer. Please state your name and your relationship to the participant. As legal guardian of ______ do you provide your consent for him (her) to participate in this research, to affirm this statement, simply say, "I give my permission."

Thank you, and let's schedule a time for the interview.

[end recording]

APPENDIX D

Research agenda page for online interviews

Research

Briefing statement

First, thank you for taking the time to do this. I know you have things to do, and working my project into your schedule is much appreciated. Before we start the video that is designed to walk you down memory lane of your AREA154 experiences, I wanted to brief you a little on the project and your role in it.

- **Step one:** A little about what I'm going – briefing + That whole consent thing (The permission documents).
  —
- **Step two:** A little question and answer session where we talk about some of your social behaviors
  —
- **Step three:** Watch the video here. Now that you've read the questions let's take that walk down memory lane.
  —
- **Step four:** The interview – I will be asking you questions that focus

Top A.R.K. Agents

	USER NAME	POINTS
1	3-christiana-tautolo	500
2	6-Emely-Viveros	484
3	6-Erick-Ramirez	469
4	4-Omar-hazeen	460
5	3-miriam-perez	455

on your experiences with the AREA154 system, your interactions with it, and how those interactions affected you and your feelings of confidence in STEM-related subjects.

—

- **Step five:** I might schedule a follow-up call or Zoom call to ask follow up questions.

That's it!

Your responsibility as a participant *is to provide honest, trustworthy, and well thought out responses. There are NO WRONG ANSWERS. If there is reason to be critical, be critical. Critical evaluation can have positive effects as well as effects that would be considered not so great. All data is valuable, and if there are problems with the system, your feedback will help make for a better, more robust experience in the future.*

If you've read the interview questions, then you're ready to proceed. [Review video begins]

PERMISSION

STEP 1

You've been CHOSEN to participate in a study that focuses on the technology design used for the AREA154: Apocalypse Div. Chemistry class. Here's how this works:

- If you are over 18: **Click here**
- If you are under 18: **Click here**

You might want to open and save a copy to your device.
Cultural information

STEP 2

The research is specifically geared to Hispanic psychosocial traits. In this next part, can you take a minute and answer the questions in this survey.

—–

1. Can you describe a little bit about your priorities?
2. What would you say are the top five most important areas of your life?

6	6-Cynthia-Agosto	403
7	3-Keila Serrano	400
8	4-rodrigo-rodriguez	400
9	5-Jessie-JImenez	335
10	5-steven-bello	335
11	6-Isaiah-Garcia	314
12	6-Liliana-Ruiz	275
13	1-Amaya-Mcwilliams	260
14	1-Elyssa-Mancilla	205
15	4-Alexis-esqueda	195
16	1-Aysel-Franco	185
17	4-Branden-Herrera	165
18	6-Megan-Valdez	165
19	5-nadia-favela	155
20	6-Bryahjahne-Smith	150

3. What would you say are your responsibilities are each day when you get home from school?
4. If schoolwork is done at home, when does that time usually occur? How frequently did you do your homework at home?
5. Cultural influence survey: **Click here.**

A Time to Reflect

STEP 3

Watch this video. It was made so that you can recall some of the experiences and memories you had during your time in that classroom.

—

What I will ask you

STEP 4

The questions I will ask you in the video are below

You will be provided some time to look over them and think about them before the interview begins.

Perceptions of success:

1. Tell me about how you perceived your confidence level in STEM subjects (your freshman biology class for example), prior to the year in AREA154.
2. Talk about your level of confidence while enrolled in the AREA154 program.
3. Were there areas (case files or specific trainings) of the program that you felt more confident than others?
4. What sorts of behaviors are common for you when you feel confident in a subject *(levels of attention, actions engaged in during class, study habits, order in which work is completed – before other subjects or after)*?
5. Can you talk about occasions when you exhibited these behaviors in our program?
6. As I mention different aspects of our program can you talk about which elements would lead you towards behaviors demonstrating a sense of confidence in this STEM subject.

21	3-Leopoldo-Martinez	145
22	4-Kaydense-Matuu Malepeai	135
23	6-Lawrence-Henzon	133
24	1-Maria-Salgado	130
25	1-soowut-rodriguez	125
26	1-Beatrice-Corona	115
27	4-Miguel-Diaz	115
28	6-Zoe-Boatright	110
29	5-Damian-Lamadrid	105
30	3-Nancy-Pedraza	100
31	4-candice-sumaran	100
32	6-Gael-Manriquez	94
33	1-Alayjah-Collins	90
34	1-Nicholas-Litton	86

1. *The central location of all learning content*
2. *Daily posts of class activity*
3. *Content organized as case files*
4. *Downloadable interactive PDFs*
5. *PDF – The Briefing Icon (**Sample to view**)*
6. *PDF – Media Icons (**Sample to view**)*
7. *PDF – The comic book inspired panel design (**Sample to view**)*
8. *PDF – The use of full color*
9. *The SRTs – Instant feedback*
10. *The SRTs – Retakes*
11. *The ATN – Dedicated place for classwork*
12. *The ATN – signatures & feedback*
13. *The ATN – Flexible deadlines*
14. *The ATN – As a tool for learning*
15. *The Leaderboard – top agents*
16. *Achievement points – ranking*
17. *Achievement points – as a currency for extra credit (did you use?)*
18. *The Examulation – the experience as a tool for assessment.*
19. *The AREA154 theme – to foster engagement*
20. *The AREA154 theme – applicability to the world around you / changed perceptions*

35	6-henry-aguilera	80

Away from class

1. In general, what were your experiences like when trying to do school work at home?
2. Did you ever attempted to access the site on a device besides your school Chromebook? If so, what did you attempt to use?
   1. *Describe any times you may have tried to access the site when in the car or on the go.*
3. How did your level of confidence change with this STEM subject when you engaged with it at home?
4. If, you did attempt to do AREA154 work at home when, where would it take place?
5. Describe how the construction of the program played a role in your ability to get the information you needed to complete work at home?
6. Where there times where you couldn't get what you needed to complete the tasks? What did you usually do to adapt?
7. How frequently did you talk about AREA154 content or experiences at home with parents or other family?
   1. How did they react?
   2. *Would you say this level of conversation was normal for all your STEM classes?*

Thematic elements – A sense of purpose

1. The class was themed around some pretty extreme topics. How did you feel about the thematic approach to teaching STEM-related topics?
2. Did you feel that the "Apocalypse" was theme was interfering with your ability to understand the content?
3. Which case file to you recall having the biggest impact on you?
   1. *What did that impact spur you to do?*
4. Did you feel that the application of the survival theme of this STEM class empowered you in any way?
5. Did you feel that this class provided a way for you to take care of your friends and family?
6. Was that part of your motivation to learn?
7. In an actual event, do you think your parents or other family would have turned to you for input on what to do?
8. How would you describe any impact the AREA154 STEM experience had on your perceptions of the world around you?

Academic perspectives

1. Would you describe yourself as academically in comparison to the rest of your immediate family?
2. What is being in a traditional science environment like after having spent time in an ulearning (AREA154) climate?
3. How would you describe your grade in the AREA154 STEM experience as opposed to other science-related class you have had?
4. How would you describe how much you feel you learned in comparison to other STEM subjects?
5. Did your experience in AREA154 influence your confidence to take more STEM related courses?
   1. *If it did, what courses did you consider?*
6. Did your experiences in AREA154 influence you in your possible career choices? If it did, what careers did you consider?
7. How would you describe your level of confidence in STEM subjects now compared to where you started at the beginning of the year?
8. Did you experience any feelings of community while a part of the program? If you did, can you talk about how that affected your sense of success in the class?
9. Do you think that the AREA154 program design I could be successful if taught by a different teacher?
   1. What traits would an instructor need to have for this type of

curriculum to produce the same sorts of success-like behaviors as it did in you?

10. Give this some thought…. If you could change any part of the SRT that might supply you with more confidence in the subject area, what might that be?

My Achievements

You must be logged in to view earned achievements

Days in Training

Days in Training

Select Month

AREA154: A.D.

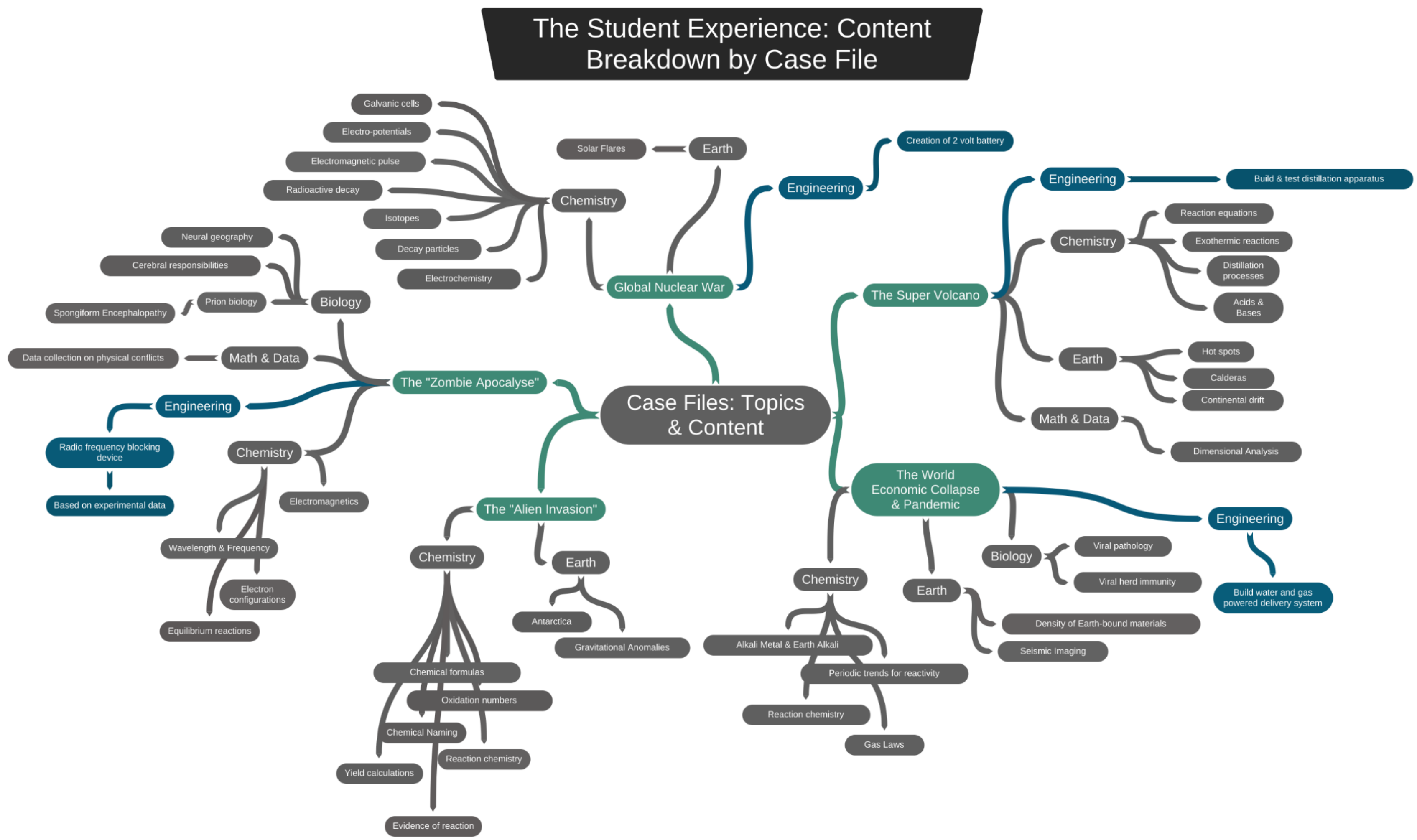
February 2021

M	T	W	T	F	S	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28

« Jan

APPENDIX E

AREA154 case file content flow chart


The Student Experience: Content Breakdown by Case File
Case Files: Topics & Content
Global Nuclear War
Earth
Solar Flares
Chemistry
Galvanic cells
Electro-potentials
Electromagnetic pulse
Radioactive decay
Isotopes
Decay particles
Electrochemistry
Engineering
Creation of 2 volt battery
The Super Volcano
Engineering
Build & test distillation apparatus
Chemistry
Reaction equations
Exothermic reactions
Distillation processes
Acids & Bases
Earth
Hot spots
Calderas
Continental drift
Math & Data
Dimensional Analysis
The World Economic Collapse & Pandemic
Engineering
Build water and gas powered delivery system
Biology
Viral pathology
Viral herd immunity
Earth
Density of Earth-bound materials
Seismic Imaging
Chemistry
Alkali Metal & Earth Alkali
Periodic trends for reactivity
Reaction chemistry
Gas Laws
The "Alien Invasion"
Earth
Antarctica
Gravitational Anomalies
Chemistry
Chemical formulas
Oxidation numbers
Chemical Naming
Reaction chemistry
Yield calculations
Evidence of reaction
The "Zombie Apocalyse"
Biology
Neural geography
Cerebral responsibilities
Prion biology
Spongiform Encephalopathy
Math & Data
Data collection on physical conflicts
Engineering
Radio frequency blocking device
Based on experimental data
Chemistry
Electromagnetics
Wavelength & Frequency
Electron configurations
Equilibrium reactions

APPENDIX F

Interview questions

Questions for multi-active cultural behaviors

- How would you describes your work habits at home?
- What are your primary methods of communicating and gathering knowledge?
- How do you address conflicts between peers or between your parents?
- How would you describe conversational patterns in your home, between orderly and chaotic?
- How would you describe your personal priorities between family and schoolwork?
- How much physical body language do you use when communicating with family members?
- How well do you deal with changes in plans?
- How important is it for you to include a family member's feelings when telling them something troubling?
- How important is your reputation with your family in comparison to your reputation with the general public?
- How frequently do your family members include people they know from work in their social circles?

Interview questions for developing confidence in STEM uLearning

- How would you describe your confidence in STEM subjects before enrolling in the AREA154 program?
- How would you describe your confidence while enrolled in the AREA154 program?
- What areas (case files or specific trainings) did you feel the most or the least confident in?
- What sorts of behaviors do you exhibit in any class where you feel confident about your success?
- In what parts of the AREA154 program do you recall exhibiting those same behaviors?
- Please provide details about your experiences with each of these elements of the AREA154 system:
    - The centralization of the content on one website.
    - The presentation of daily class activities on the front page of the site.
    - Content (lessons and units) organized as "case files" and "trainings."
    - The interactive "HyperDoc"-style PDF documents.
    - On the PDF: the briefing icon (provide video instructions for each section).
    - On the PDF: media icons (provide additional task-based instruction).
    - On the PDF: the comic book-inspired design (content presented in panels).

- On the PDF: use of full-color documents for communication.
- On the SRTs: instant feedback.
- On the SRTs: ability to retake formative assessments.
- On the ATN: as a dedicated place for classwork (notebooks for only AREA154 use).
- On the ATN: for signature feedback.
- On the ATN: as a learning tool.
- Flexible deadlines, both online and in class.
- The AREA154 Top Agent Leaderboard (gamification element).
- Achievement points and ranking among peers (gamification element).
- The “Examulation” summative assessment simulation.
- The AREA154 thematic approach.

Interview questions for data about students’ behaviors outside the classroom

- Describe your experiences trying to work at home on your own.
- What types of devices did you use to access the site besides the school-provided Chromebook?
- How did your confidence in doing the work change when you were no longer at school?
- From what locations outside of school did you attempt to engage in site-related work?
- How did the site and the program design help or hinder you in working outside the classroom?
- How frequently did you talk about your experiences in the AREA154 program to your family at home?

Interview questions for opinions on the thematic elements

- How did you feel about the thematic approach to teaching STEM topics?
- Did you feel that the intensity of the “apocalypse” theme interfered with your ability to learn?
- What case file had the biggest impact on you personally?
- Did you feel empowered in any way by the real-life applications of the survival chemistry?
- In an actual event, do you think your parents might turn to you for input?
- How would you describe any impact the AREA154 experience had on your perceptions of the world around you?

Interview questions for perceptions of experiences

- How would you describe yourself academically in comparison to the rest of your family?
- What was your experience like of being in a STEM classroom after being in the AREA154 system?
- How would you describe your grade in AREA154 in comparison to those you earned in other STEM classes?
- How would you describe how much you learned in the AREA154 program in comparison to other STEM classes?
- Did the AREA154 program influence your potential career choices?
- How would you describe your overall STEM confidence at the end of the program in comparison to where it was at the beginning of the year?
- Did your experience in the AREA154 program influence your choice of a STEM course for the following year?
- Based on your experience and your observations of the program, do you feel the course could be adequately taught by a teacher other than the one who was your instructor?
- What sorts of professional or personal traits would an instructor need to teach the program successfully?

APPENDIX G

Situational multi-active questions

Multi-active behavioral influences – Scenarios posited to students for response

1. You are at home and have a variety of jobs on your to-do list. What is your strategy for getting things done?
    a. I tend to start one then move to another and eventually work my way around to getting all the work done.
    b. I start on one task, finish it then move on. I tend not to move on until the first thing is done.
2. When you are at home, walk to the kitchen and see something on TV that peeks your interest, but you're not really watching the show. What is your conversational impulse?
    a. Speak up and make a comment, people do that in my house, TV is the source of a lot of opinioned conversation.
    b. I tend to not talk much unless I feel that I need something from someone.
3. You and your mom are in a difference of opinion, arguing. You says that she hurt her feelings because she did x, y, and z. things. She says something back that makes you frustrated. How do you likely respond?
    a. Focus on the facts of the situation and stay focused on the point of the argument.
    b. Argue back, possibly get angry that she doesn't see how you feel.
4. You are in the middle of a family dinner and the conversation is lively. You suddenly feel like you have something to say, what would you normally do to get your voice heard?
    a. Wait until there is a break in the conversation to jump in
    b. Jump into the conversation when the timing for your comment seems best
5. You have work to do, say it's for your future career goals, or maybe just homework. Your mom asks for your help in the kitchen. What might your response be?
    a. "Give me 5 minutes to finish up this work and I'll be right there."
    b. "OK, be right there." – with little hesitation you get up to go help.
6. Something came up at school today about teen pregnancy. You're curious about the subject, what do you do?
    a. Ask an older friend or trusted family member
    b. Search the topic up on your own, figure it out by yourself
7. You're in a fun conversation with your friends or family. What would that conversation look like?
    a. Tend to use lots of facial expressions and body language when I talk
    b. Tend to be pretty still with minimal hand movements, generally less expressive
8. You're walking around a mall or big store and your mom sees a friend of hers. What is the likely response and would you have a similar response if you saw a

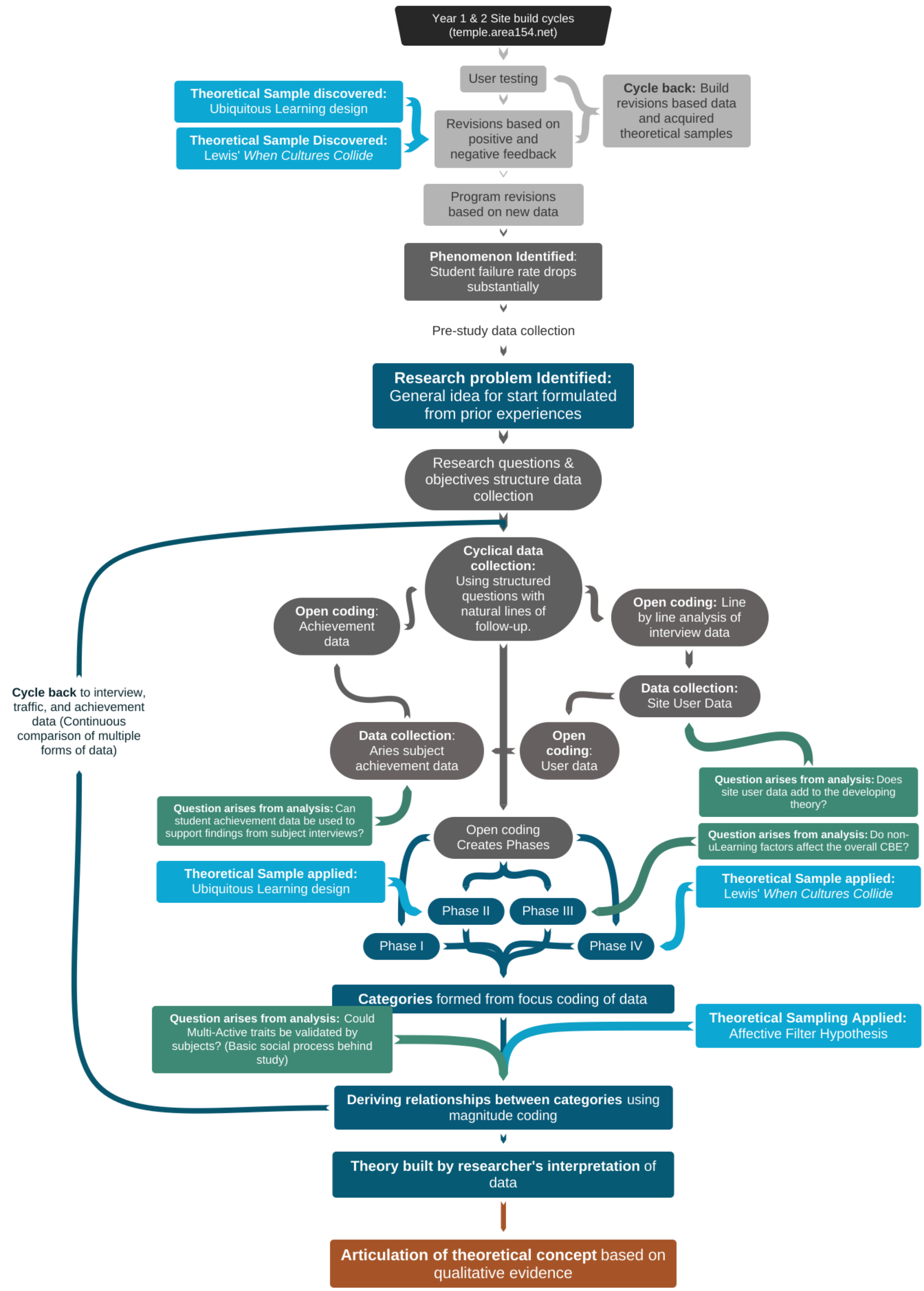
friend of yours?

   a. Wave, maybe pat on the shoulder, brief conversation
   b. Excitement, maybe a hug, a longer conversation about how life is going

9. You are planning to get some homework done this afternoon, maybe you're a little behind, it's important that you find a way to get it done. Suddenly, your mom (or someone older in your family) says she has free tickets to go to the movies and needs you to baby sit your siblings, you'll be paid, but how do you feel now about the change in plans?
   a. I'm pretty go with the flow – I'll adjust somehow
   b. Feel disoriented, maybe a little frustrated because your plans are now changed
10. Let's say that you have a decently active Tok-tok account. It's not huge, mild to moderate traffic. Which of the following comment would mean more to you?
    a. Your mom, dad, respected sibling, says they really like your channel.
    b. Your comments from the people that watch the content.

APPENDIX H

Full Grounded Theory Flow Chart


Year 1 & 2 Site build cycles (temple.area154.net)
User testing
Theoretical Sample discovered: Ubiquitous Learning design
Theoretical Sample Discovered: Lewis' When Cultures Collide
Revisions based on positive and negative feedback
Cycle back: Build revisions based data and acquired theoretical samples
Program revisions based on new data
Phenomenon Identified: Student failure rate drops substantially
Pre-study data collection
Research problem Identified: General idea for start formulated from prior experiences
Research questions & objectives structure data collection
Cyclical data collection: Using structured questions with natural lines of follow-up.
Open coding: Achievement data
Open coding: Line by line analysis of interview data
Data collection: Site User Data
Cycle back to interview, traffic, and achievement data (Continuous comparison of multiple forms of data)
Data collection: Aries subject achievement data
Open coding: User data
Question arises from analysis: Does site user data add to the developing theory?
Question arises from analysis: Can student achievement data be used to support findings from subject interviews?
Open coding Creates Phases
Question arises from analysis: Do non-uLearning factors affect the overall CBE?
Theoretical Sample applied: Ubiquitous Learning design
Theoretical Sample applied: Lewis' When Cultures Collide
Phase II
Phase III
Phase I
Phase IV
Categories formed from focus coding of data
Question arises from analysis: Could Multi-Active traits be validated by subjects? (Basic social process behind study)
Theoretical Sampling Applied: Affective Filter Hypothesis
Deriving relationships between categories using magnitude coding
Theory built by researcher's interpretation of data
Articulation of theoretical concept based on qualitative evidence

APPENDIX I

Student Profiles Analysis for Multi-Active traits and Achievement

Table I-1 Multi-Active assessment and Academic profile — No. 1-ranking participant

Student ID	Fall Grade %	Spring Grade %	Year-Long Average	Year-Long Trend		Multi-Active Score (max = 11)	AREA154 vs. Other Core Subjects (2nd Sem)	
STU-F-4-1	101.5	105.5	102.3	1QF	A	2	STEM	A+
				2QF	A		Math	A+
				FSG	A+		English	A-
				1QS	A		History	A
				2QS	A+			
				SSG	A+		Previous STEM grade (freshman)	C
							Took STEM course the following year	Yes

	In-Class Login % Over Course Year	Login % at Home Over Course Year
AREA154 Backend Login Frequency (Data extrapolated based on usage across a one-month time frame using "Simple History" WordPress backend plug-in.)	99%	87%
AREA154 Daily Login Duration (Data extrapolated based on usage across a one-month time frame using "Simple History" WordPress backend plug-in.)	48 min/class period	17 min/day

Memos on participant's in-class behaviors: The student demonstrated an exceptional level of quiet and focus. She had one of these most disciplined routines of any of the students in her class, which supports her in-class frequency for class login. She would always arrive in class, open the ATN, and log into the site even if it was not a focal point of the day's activities. It should be noted that this student had an IEP for social anxiety. Apparently it had been worse during her freshman year, which may explain why her grade was so much lower than her grade in AREA154. There is no known official reason for her turnaround during her sophomore year. Her grade in the class was due to her diligence, OCD-type fixation on details for completing her ATN, and the application of achievement points at the end of the grading period. *(Observations recalled from 2019–2020 school year—9 months of class time.)*

Memos from interview & observations: The student has made great strides in gaining confidence within her ability to communicate. This could have occurred because the interview took place over Zoom rather than face-to-face. The subject's responses were clear but short and concise, not displaying much need or desire to expound upon her experience. She noted that the STEM class was one of her favorites and that she would frequently engage in extracurricular research on topics such as the Yellowstone caldera and the possibility of electromagnetically induced zombies. As a video game player, the zombie theme was one of her favorites. The topics of the uLearning program also (according to her mother) served as one of the stepping-stones that helped her learn how to reach out and speak to people around her. According to her mother, as noted in her IEP meeting, she would talk about the content in AREA154 more thATV anything else from any other class that year. What is rather remarkable is how many specific details she could recall about nuances in the case-file PDFs that I had forgotten about—things that clearly had made an impact on her. She noted that when we used professional material to block EM, it only worked if the phone was completely enveloped in it. Even the tiniest hole would cause the phone to ring. (*Interview time: 73 min.*)

Codes: *Attentive-focused, multi-linear non-conformant (MLNC), achiever-type, grade-motivated, science-minded, positive psycho-social integration (+PSS), curious, atypical, top grade (tied with one other classmate), family-share, better than frosh, 2ndS>1stS, confident, family-centered, routine-centered.*

Note: The student ID – Stu – gender – multi-active rating – STEM GPA ranking among participants.

Table I-2 Multi-Active assessment and Academic profile – No. 2 Ranking Participant

Student ID	Fall Grade %	Spring Grade %	Year-long Average	Year-long trend	Multi-Active Score (max=11)	AREA154 vs. other core subjects (2nd Sem)	
STU-F-6-2	99.1	97.1	98.1	1QF A 2QF A FSG A+ 1QS A 2QS A SSG A	6	STEM Math Adv English History Previous STEM Grade (Freshman) Took STEM course following year	A+ A+ A A A Yes

	In-class Login % over course year	Login % at home over course year
AREA154 backend log-in frequency: (Data extrapolated based on usage across a one month time frame using "Simple History" WordPress backend plug-in.)	94%	88%
AREA154 Daily log-in duration: (Data extrapolated based on usage across a one month time frame using "Simple History" WordPress backend plug-in.)	38 min	25 min

Memos on participant's in-class behaviors: This subject demonstrated a high degree of focus on achievement. Much of that achievement drive seems to stem from the mother who works as a manager at a large company (somewhere in Corona, Ca – student was unclear on precisely what parent did for a living). I received several emails from the parent over the course of the year any time attendance or grades appeared to become an issue. Subject would be considered highly managed, but also provides a sensation that she longs for the social interaction that her home life seems to constrain. Often very talkative in class with peers. She seemed not to get as much done in class. Instead, she would complete most of her work at home – as evidence of the at-home logins and the timestamps provided by the SRTs taken across the year. (Observations recalled from 2019-2020 school year – 9 months of class time.)

Memos from interview & observations: Student was very talkative despite her statements to the contrary about "only talking when she felt she needed to do so. Her answers were honest and straight-forward. She did not appear to be a fan of the Examulations due to the shifting of the teams. She was quite comfortable with the table group she was placed with over the course of the year. As she had risen in rank to "Special Agent" she would always move her seat back to the location with one or more of her in-class social associates. Her social tendencies (she responded to her phone twice during the interview) seemed to only be curbed by the ridged influence her mother has in her life. She was also on a computer rather than the school-provided Chromebook. This indicates that this subject may be in a higher strata of socioeconomic influence than her peers. There did not appear to be any indication that she did any extracurricular research on the program topics. Subject is intelligent and socially savvy. Her recall, in my opinion, should be better given her "earned" grade. Her interview left me with the feeling that she was more involved with the sort of behavior associated with a term well-trained students use to pass classes they lack a specific interest in called "learn and burn". Learn it for when you need it, then burn it down forever, or something to that effect. (Interview time: 83 min)

Codes: *MomManaged, focused, Multi-Linear non-conformant (MLNC), Social, Multi-Linear non-conformant (MLNC), Forced- Positive Psycho-social Integration (F+PPI), Top Grade (Tied with one other class), Confidence, Routine-centered*

Note: The student ID – Stu – gender - Multi-Active rating – STEM GPA ranking among participants

Table I-3 Multi-Active assessment and Academic profile – No. 3 Ranking Participant

Student ID	Fall Grade %	Spring Grade %	Year-long Average	Year-long trend	Multi-Active Score (max=11)	AREA154 vs. other core subjects (2nd Sem)
STU-M-4-3	88.8	99.5	94.2	1QF A- 2QF A- FSG B 1QS B 2QS A SSG A+	4	STEM A+ Math A- English A History A- Previous STEM Grade (Freshman) B Took STEM course following year Yes*

	In-class Login % over course year	Login % at home over course year
AREA154 backend log-in frequency: (Data extrapolated based on usage across a one month time frame using "Simple History" WordPress backend plug-in.)	84%	62%
AREA154 Daily log-in duration: (Data extrapolated based on usage across a one month time frame using "Simple History" WordPress backend plug-in.)	49 min	30 min

Memos on participant's in-class behaviors: Participant was highly respectful, largely quiet, would volunteer to get involved with class discussions however only when no one else was willing to do so. He was heavily involved with Air Force ROTC as was the rest of his table. They would often collaborate as a team. However, after significant observation time it became clear that this subject was the driving force behind the work. While he spend time talking about the random subject content offered up by peers at the table, he was usually the one that put everyone back on task, with a little help from the instructor. When the group was separated, the other two (also in AF ROTC) would suffer large drops in productivity. One of them would simply stop and engage in distracting activities during most of the period. It should be noted that the summer after class let out, subject requested the reactants to initiate the Thermite reaction, a reaction he learned about during the Alien invasion. He dug a two-foot by two-foot by two-foot hole and successfully ran the reaction. He recorded the process and sent me the images. His dedication and willingness to apply knowledge outside the classroom is rare – or it is at least rare for them to do it and then send pictures of their "achievements".(Observations recalled from 2019-2020 school year – 9 months of class time.)

Memos from interview & observations: The interview took place in what looked like a "study". Pictures of military aircraft hung on the walls and what appeared to be framed medals were on a bookshelf next to books that were too far away to see the title. After some pre-interview questioning, subject revealed that his family had been in the military in some form for the last 3 generations. The structure that is brought about by having a military family

might explain why this subject scored so low on the Multi-Active scale. While his immediate and extended family appeared to identify with Hispanic psycho-social behaviors, the military appears to have provided some form of assimilation that is more synchronous with the school culture that is so prevalent in US schools. Subject discussed how he would often do work at home because he was comfortable with the AREA154 system and that may explain why he was able to converse in class yet appear to keep his grades up. (*Interview time: 65 min*)
Codes: *Managed, focused, disciplined, ROTC, Social, Multi-Linear non-conformant (MLNC), Forced- Positive Psycho-social Integration (+PSI), Routine-centered, Top Grade, Better than frosh, 2ndS>1stS, Extra-effort, Confidence, Atypical*

Note: The student ID – Stu – gender - Multi-Active rating – STEM GPA ranking among participants

* Chose to take physics and additional STEM engineering class

Table I-4 Multi-Active assessment and Academic profile – No. 4 Ranking Participant

Student ID	Fall Grade %	Spring Grade %	Year-long Average	Year-long trend	Multi-Active Score (max=11)	AREA154 vs. other core subjects	
STU-F-8-4	92.1	93.5	92.8	1QF A+ 2QF A FSG A- 1QS B+ 2QS A SSG A	8	STEM Math English History Previous STEM Grade (Freshman) Took STEM course following year	A A B A- A Yes**

	In-class Login % over course year	Login % at home over course year
AREA154 backend log-in frequency: (Data extrapolated based on usage across a one month time frame using "Simple History" WordPress backend plug-in.)	89%	55%
AREA154 Daily log-in duration: (Data extrapolated based on usage across a one month time frame using "Simple History" WordPress backend plug-in.)	39 min	22 min

Memos on participant's in-class behaviors: Participant was notably social and had to be moved once during the course of the year, not for her own sake, but for the sake of others. She noted that she was skilled at catching up at home when she needed to do so. This was not so much the case with the other to students. The would get so caught up in the conversation that the socialization dominated their full attention. Subject was also a part of that, however, her rather disciplined nature proved to overcome that obstacle. Participant demonstrated well-developed coping mechanisms for home and school. *(Observations recalled from 2019-2020 school year – 9 months of class time.)*
Memos from interview & observations: Subject demonstrate some hesitance with the interview, maybe just nervous. She appeared to be honest but her very considerate nature may require me to go back and use that as a filter as coding of her comments about the uLearning system is completed. During the interview, it was noted that she was

responsible for two younger siblings. Often times getting them taken care of and assisting her Mother would take priority and she would often be left to do school related business later at night. As the oldest of three she appears to have taken on a bit of a "sister mom" role. Both parents worked and as the oldest and assumed to be most capable, she was tasked to take on more responsibilities than her siblings. When asked, she said she didn't seem to mind, rather "It just is what it is." Reflecting on her statement, it seems to tightly align with Lewis' observations about Hispanic cultures, family priorities, and the easy-going nature when confronted with changes in plans. Subject demonstrated active recall of past casefile information with impressive accuracy and frequency. (*Interview time: 61 min*)
Codes: *Sister-mom, disciplined, Family-focused, Social, Positive Psycho-social Integration (+PSI), Achiever, First-born, Top Grade (tied with one other class), 2ndS>1stS, (~)Emotional Gratification.*

Note: The student ID – Stu – gender - Multi-Active rating – STEM GPA ranking among participants

** Student was in Bio-Med pathway and had to take Bio-Med II as part of the program

Table I-5 Multi-Active assessment and Academic profile – No. 5 Ranking Participant

Student ID	Fall Grade %	Spring Grade %	Year-long Average	Year-long trend		Multi-Active Score (max=11)	AREA154 vs. other core subjects (2nd Sem)	
STU-F-6-5	88.5	95.2	91.9	1QF	B-	6	STEM	A
				2QF	B		Math	B-
				FSG	A-		English	C
				1QS	C		History	D-
				2QS	A			
				SSG	A		Previous STEM Grade (Freshman)	C
							Took STEM course following year	Yes

	In-class Login % over course year	Login % at home over course year
AREA154 backend log-in frequency: (Data extrapolated based on usage across a one month time frame using "Simple History" WordPress backend plug-in.)	91%	25%
AREA154 Daily log-in duration: (Data extrapolated based on usage across a one month time frame using "Simple History" WordPress backend plug-in.)	51 min	5 min

Memos on participant's in-class behaviors: Participant did not leave much of an impression across the year. Quiet, reserved, task-minded, she was not very conversational (perhaps due to some issue with her conversational English: No, just checked Aeries database and she was advanced for language development). There is no recollection of her talking with anyone, she was on task whenever she was observed in her table teams. Also, she would appear to work alone during Examulations. Though, this sort of action was normal among students that had a completed ATN and knew how to survive. Well-prepared students often refused to share. Other than these, recollections of this student are vague. *(Observations recalled from 2019-2020 school year – 9 months of class time.)*

Memos from interview & observations: Often times during the interview I would get the feeling that she would stop and rephrase or say something that wasn't entirely the full response due to a cultural imperative to respect the feelings of others. She had an older brother that had moved out of the home. As she was the oldest sibling many of the chores that the mom would do were passed to her. As such, after school time was often dominated with family-related issues. The parents both appear to be in blue-collar type work (subject stated parents work at night – non-typical of white-collar work hours) He final grade in AREA154 was notably higher than her other subjects. Something – yet unclear – about this environment that promoted her success. Subject's recall of events during the year lacked specific detail, however, she was clear about her interest in the class and how she felt about being a part of the class; it appeared to have a positive impact on her. (*Interview time: 55 min*)
Codes: *Sister-mom, Interest-driven(?), Family-focused, Non-social, Positive Psycho-social synchronization (+PSS), Achiever, Second born (oldest currently at home), Blue-collar parents, Top grade, (~)Multi-Linear Conformant ((~)MLC), Better than frosh, 2ndS>1stS*

Note: The student ID – Stu – gender - Multi-Active rating – STEM GPA ranking among participants

Table I-6 Multi-Active assessment and Academic profile – No. 6 Ranking Participant

Student ID	Fall Grade %	Spring Grade %	Year-long Average	Year-long trend		Multi-Active Score (max=11)	AREA154 vs. other core subjects (2nd Sem)	
STU-F-7-6	90.2	92.3	91.3	1QF	B-	7	STEM	A-
				2QF	B-		Math	C-
				FSG	A-		English	A+
				1QS	A+		History	B-
				2QS	B+			
				SSG	A-		Previous STEM Grade (Soph. Bio Med I)	B
							Took STEM course following year	Yes**

	In-class Login % over course year	Login % at home over course year
AREA154 backend log-in frequency: (Data extrapolated based on usage across a one month time frame using "Simple History" WordPress backend plug-in.)	82%	15%
AREA154 Daily log-in duration: (Data extrapolated based on usage across a one month time frame using "Simple History" WordPress backend plug-in.)	33 min	23 min

Memos on participant's in-class behaviors: Participant demonstrated intermittent times of focus and attention to time-dependent tasks. She had a propensity to put off in class content in favor of socializing with the team at her table. She was a cooperative student and minded classroom authority. On every occasion where she was reminded that there was work to be completed, she responded. However, her peers were less cooperative and would tend to draw her out into discussion eventually. She was a year older (11th grade) than most of the students in the class (typically 10th graders), and perhaps that made her presence there a bit of novelty. She displayed above-average interest and curiosity about the AREA154 themes. She would often leave her table team and ask questions about the

implications of the assumptions made within the case files. *(Observations recalled from 2019-2020 school year – 9 months of class time.)*
Memos from interview & observations: The interview was on her phone because the internet was not a solid connection. All her previous science experiences in high school were BioMed classes. Nothing else. She discussed how science classes were always overwhelming for her (a possible perception that she couldn't do well or lacked confidence). In general she spoke casually about being "bored" with traditional classes and asked about why teachers don't take applicability into account when planning curriculum. She assumed it was part of her job. I spoke to her about how most teachers teach how they learn and that over the last 15 years, the brain wiring has changed significantly due to growing up with the internet and the avalanche of media. Her older sister was in the room during the call and subject would often turn to her for approval (assumed) when she was answering questions about her own opinions about elements of the AREA154 program. (*Interview time: 72 min*)
Codes: *Family focused, Respectful, Social, Negative Psycho-social Synchronization, Second-Top Grade, Interest, Curiosity, Multi-Linear Conformant (MLC), Parents-Non English, Better than frosh, 2ndS>1stS, Emotional Gratification*

Note: The student ID – Stu – gender - Multi-Active rating – STEM GPA ranking among participants

** Student was in Bio-Med pathway and had to take Bio-Med II as part of the program

Table I-7 Multi-Active assessment and Academic profile – No. 7 Ranking Participant

Student ID	Fall Grade %	Spring Grade %	Year-long Average	Year-long trend		Multi-Active Score (max=11)	AREA154 vs. other core subjects (2nd Sem)	
STU-F-9-7	90.1	92.3	90.8	1QF	B-	7	STEM	A-
				2QF	B-		Math	A-
				FSG	A-		English	B+
				1QS	A+		History	B-
				2QS	B+			
				SSG	A-		Previous STEM Grade (Soph. Bio Med I)	B
							Took STEM course following year	No***

	In-class Login % over course year	Login % at home over course year
AREA154 backend log-in frequency: (Data extrapolated based on usage across a one month time frame using "Simple History" WordPress backend plug-in.)	95%	45%
AREA154 Daily log-in duration: (Data extrapolated based on usage across a one month time frame using "Simple History" WordPress backend plug-in.)	48 min	36 min

Memos on participant's in-class behaviors: Participant entered the class after three weeks into the school year. It was recommended to her by her previous high school math teacher that she move to a school that offered more resources to match her potential academically. Subject displayed all of the model behaviors of a "good student." She was cooperative and responsive to correction. The student was more motivated by the act of learning interesting

information than she was interested in grades for the sake of getting good grades. She was a senior, the only senior in the class, and her level of maturity may have contributed to her rather Linear-Active behaviors, even though most of her family appeared to be very closely attenuated to Lewis' assumptions about Hispanic psycho-social behavior. Parents worked blue-collar jobs – I recall something about her mom working odd hours at the post office and how she was often responsible for taking care of her younger sister. *(Observations recalled from 2019-2020 school year – 9 months of class time.)*

Memos from interview & observations: After the cultural interview segment, both subject tended to show tendencies toward Linear behaviors. Subject stated in a follow-up to the cultural questions that she is considered "cold" by her family as she appears to present more logic than feelings. She additionally noted that she was the outlier in that sense from the rest of her family. She noted during the interview that she would take her phone with her on family picnics and work on AREA154 content. She stated it was for two reasons, she was highly interested in the content, and she enjoyed sharing it with an equally interested younger cousin who would frequently ask her about the course content. The very notion that she would take classwork to a family gathering would tend to suggest that she sees herself as a sort of cultural outsider. Her curiosity about the course content and her willingness to now question everything (which she stemmed from the AREA154 course). Teachers from her previous school Baypoint Academy (her math teacher specifically) stated that this particular student had an academic aptitude that far exceeded anyone in her class. For that reason, she was encouraged to transfer from Baypoint to San Jacinto High School. During the interview, subject demonstrated a rather impressive command over her recall of specific elements of the AREA154 program. She noted the content more specifically associate with casefiles that had a sort of "bigger than life" feel and induced a sense of anxiety. It appears the anxiety both drove her curiosity, and knowing more allowed her to gain command over that anxious feeling. This forced feedback loop seems to assist in giving rise to her attitude towards questioning everything, especially the mainstream media. (*Interview time: 80 min*)

Codes: *Family-focused, Respectful, Social, Positive Psycho-social Integration (+PPI), Top Grade, Interest, High-Curiosity, Changed World-View, High Multi-Linear Conformant (HMLC), Family-Share, Better than frosh, 2ndS>1stS, Remote access, Atypical*

Note: The student ID – Stu – gender - Multi-Active rating – STEM GPA ranking among participants
*** Subject was a Senior

Table I-8 Multi-Active assessment and Academic profile – No. 8 Ranking Participant

Student ID	Fall Grade %	Spring Grade %	Year-long Average	Year-long trend		Multi-Active Score (max=11)	AREA154 vs. other core subjects (2nd Sem)	
STU-M-9-8	82.1	90.8	86.5	1QF 2QF FSG 1QS 2QS SSG	B+ B B- A A- A-	8	STEM Math English History Previous STEM Grade (Freshman) Took STEM course following year	A- D A+ A- C Yes

AREA154 backend log-in frequency: (Data extrapolated based on usage across a one month time frame using "Simple History" WordPress backend plug-in.)	In-class Login % over course year	Login % at home over course year
	64%	44%

AREA154 Daily log-in duration: (Data extrapolated based on usage across a one month time frame using "Simple History" WordPress backend plug-in.)	36 min	25 min

Memos on participant's in-class behaviors: Subject was a minimalist (as memory serves) when it came to achievement. He sat with a group of friends within the class and tended to fall back on some of them for work sometimes (maybe more often than was indicated in the interview). His ATN was often sloppy and had the condensed appearance of being summarized or possibly copied from someone else. He would often only write partial sentences as answers (despite being told many times not to do that). After his first Examulation – where he was killed within the first 4 months – it dawned on him that he ought to be more mindful of having a complete ATN. I think this was even noted in the interview recording. Despite the realization, he would default back to his prior lowest-possible-effort methodologies. He sat with one of the other participants in this study and was often seen attempting to coerce help from his fellow ROTC friends. According to the backend data on the AREA154 site, the only Examulation this subject passed was the one where he was partnered with one of his ROTC friends. II would imagine it was the same friend who was helping him during class so often. Behaviors often were swayed by what "felt good to do at the time" influenced by a need for instant gratification. This impulse usually led to heavily off-topic subjects of discussion. *(Observations recalled from 2019-2020 school year – 9 months of class time.)*

Memos from interview & observations: Subject indicated that he was pretty good with the examulations, and that would need to be verified with Aeries (Verified 2/7/21 he passed 2/3 examulations). He had distinct career goals with a focus on getting into the Air Force. There was no face recording on this interview. I do not think that will impact any of the findings. He did however, indicate that he had a willingness to please and keep the emotionally positive elements of the relationship in play. I have a feeling that there was some of that in this interview. After validating some of the statements made about the Examulation it does not appear that he had any intention to misrepresent any of the information he provided. From time to time when subject would speak during the interview loud voices of children and shouting parent could be heard in background. There may be a reason why subject appeared distant and agitated. Perhaps home is not the place of peace it is for many students. (*Interview time: 54 min*)

Codes: *(~) priorities, Respectful, ROTC, Social, Second Top Grade, Minimalist, User, High Multi-Linear conformant (HMLC), Feeling-based logic, Trouble@Home, Better than frosh, 2ndS>1stS, 2ndSemResurgence*

Note: The student ID – Stu – gender - Multi-Active rating – STEM GPA ranking among participants

Table I-9 Multi-Active assessment and Academic profile – No. 9 Ranking Participant

Student ID	Fall Grade %	Spring Grade %	Year-long Average	Year-long trend		Multi-Active Score (max=11)	AREA154 vs. other core subjects (2nd Sem)	
STU-M-7-9	82.5	88.6	85.6	1QF	A	7	STEM	B
				2QF	B		Math	C
				FSG	B		English	B-
				1QS	A		History	C
				2QS	B			
				SSG	B		Previous STEM Grade (Freshman)	C-
							Took STEM course following year	Yes

AREA154 backend log-in frequency:	In-class Login % over course year	Login % at home over course year
(Data extrapolated based on usage across a one month time frame using	79%	31%

"Simple History" WordPress backend plug-in.)		

AREA154 Daily log-in duration: (Data extrapolated based on usage across a one month time frame using "Simple History" WordPress backend plug-in.)	45 min	19 min

Memos on participant's in-class behaviors: Subject demonstrated a quiet and cooperative demeanor across the course of the year. He was not notable academically however, his curiosity was something to be admired. More than just about any other student subject would stay in at lunches and breaks to engage in conversation about class topics and topics connected to those covered in the AREA154 program. Even the following year he would come and find me from across campus to ask questions that he had come up with. The student appeared to be much more of a thinker than a doer. Not driven so much by the list-driven nature of typical classes, but more so driving by things that made him curious, content that created dissonance in his mind. Also of note, his use of retakes was a little higher than most and often had to be reminded of missing work. *(Observations recalled from 2019-2020 school year – 9 months of class time.)*

Memos from interview & observations: Subject is currently a senior and changed physically, as expected. His answers were straightforward and short. He was enthusiastic about participating in the interview process and when prompted to provide more information he did so without any hesitation. I think he nature is to be brief. His family does not appear to have the same characteristic. The interview was interrupted 3 times (once by mother and twice by younger sister). Guessing, I think the sister came in because as subject stated in his interview, he often spoke to his younger sister and older brother about the class and they would often times carry on lengthy discussions over various AREA154 and related topics. Additionally, the little sister waved at the camera, perhaps aware of who was on the other side. When asked about if he share with his parents, he stated, "They don't really speak English well, so as long as my grades look good. They are pretty hands-off with school." (*Interview time: 78 min*)

Codes: *High Curiosity, Multi-Linear conformant (MLC), Parents-No English, Top Grade, Family-Share, Better than frosh, Emotional gratification*

Note: The student ID – Stu – gender - Multi-Active rating – STEM GPA ranking among participants

Table I-10 Multi-Active assessment and Academic profile – No. 10 Ranking Participant

Student ID	Fall Grade %	Spring Grade %	Year-long Average	Year-long trend		Multi-Active Score (max=11)	AREA154 vs. other core subjects (2nd Sem)	
STU-F-7-10	77.1	92.2	84.9	1QF	D-	y	STEM	A-
				2QF	D-		Math	B
				FSG	C		English	B+
				1QS	A+		History	A-
				2QS	A-			
				SSG	A-		Previous STEM Grade (Freshman)	D+
							Took STEM course following year	Yes

AREA154 backend log-in frequency: (Data extrapolated based on usage across a one month time frame using	In-class Login % over course year	Login % at home over course year
	65%	15%

“Simple History” WordPress backend plug-in.)		
AREA154 Daily log-in duration: (Data extrapolated based on usage across a one month time frame using “Simple History” WordPress backend plug-in.)	32 min	11 min
Memos on participant’s in-class behaviors: Subject demonstrated highly social tendencies. She appeared to respond well to being redirected back to work, was pleasant about the interaction – all the time. However, her level of distractibility and impulse into engaging into emotionally rewarding activities (socialization) may be the reason why she displayed such poor grades. While she was interested in our conversations during class discussions. As long as there was a “story” to be heard, she was completely focused. During class discussions, she was one of the students with the greatest degree of interaction with the instructor. However, it is at the beginning of the program where one comes to understand how the system works. Miss out on that, and her comments about how the system was “hard to understand” may start to make sense. She demonstrated a high degree of interpersonal intelligence and was often the target of table partners who needed assistance. She did not demonstrate much of the traditional “success” behaviors that would be associated with students who demonstrate high marks. She seemed to want to learn for the sake of learning but had less interest in doing the work associated with proving she learned something. However, after the first Examulation she “died” because she was not prepared. She displayed visible signs of worry. That may have been the precursor that led to the performance turnaround during the second semester. *(Observations recalled from 2019-2020 school year – 9 months of class time.)*		
Memos from interview & observations: Subject was very positive and accommodating during the interview. She appeared to demonstrate “respect reflex” and provide answers that might demonstrate answers that I would want to hear rather than the blunt truth of the matter. On several occasions, she was able to identify areas of study and general topics but could not really identify much of the specifics. She stated that the course content and how it was presented encouraged her to look up and further study topics in a way that no class (especially STEM) had done before. It could be that her intense social behavior at the beginning of the year was due to her discomfort with her previous science experiences. She did not that she experienced some anxiety with taking chemistry because “everyone said it was super hard and boring.” The interview went longer than expected due to being interrupted twice by mom that needed her for assistance with something. She’s the oldest in the family of 3 kids, and it would be logical to suggest that she constantly gets pulled into being a sister-mom to help raise the younger siblings. Being busy with family affairs would explain why so little work appears to have been done at home. She also noted that she excitedly shared class content with mom. Dad worked nights and was not around much. (*Interview time: 92 min*)		
Codes: *High Curiosity, Multi-Linear conformant (MLC), Sister-mom, Top Grade, Family-Share, Better than frosh, 2ndS>1stS, Emotional gratification, 2ndSemResurgence, Confidence, Family focused, Social*		

Note: The student ID – Stu – gender - Multi-Active rating – STEM GPA ranking among participants

Table I-11 Multi-Active assessment and Academic profile – No. 11 Ranking Participant

Student ID	Fall Grade %	Spring Grade %	Year-long Average	Year-long trend		Multi-Active Score (max=11)	AREA154 vs. other core subjects (2nd Sem)	
STU-F-7-11	78.8	88.4	83.6	1QF	F	8	STEM	B+
				2QF	C		Math	A
				FSG	C+		English	A-
				1QS	A+		History	B-
				2QS	B			
				SSG	B+		Previous STEM Grade (Freshman)	B
							Took STEM course following year	Yes

	In-class Login % over course year	Login % at home over course year
AREA154 backend log-in frequency: (Data extrapolated based on usage across a one month time frame using "Simple History" WordPress backend plug-in.)	98%	9%
AREA154 Daily log-in duration: (Data extrapolated based on usage across a one month time frame using "Simple History" WordPress backend plug-in.)	51 min	8 min

Memos on participant's in-class behaviors: Student presented what one might call "average social tendencies" for a sophomore at SJHS. She was on topic when asked, but very frequently was pulled off task but interactions with technology and table team members. Of note, she was always in class early (perhaps had a class nearby) and appeared to be prepped up and ready to go for the class period (logged into the site, ATN out). Additionally, she did very little at home. If there was any work to be done, then it was done during school. She was quiet about home life and opted to talk about current events, the topics of interest connected to the class, or video games. Also of note, subject was gone from class for about two weeks where she was able to keep up while on the road and at the airport. She noted once before class that she was at the airport in the back of her mom's car and needed to know what was due. *(Observations recalled from 2019-2020 school year – 9 months of class time.)*

Memos from interview & observations: Subject was verbose during the interview. While not confirmed, the conversation seemed to drag on in a manner befitting a person who was relieved to be in the interview and not somewhere else. Subject talked about issues with site organization at the beginning of the term, but once she, in her words, "actually started to pay attention" she noted that the organization of the site was quite easy to follow. No follow-up questions were used to discuss why she felt paying attention to the class at the beginning was difficult. Subject noted that her family had uprooted due to financial issues, though did not disclose when this happened or why it happened. (*Interview time: 88 min*)

Codes: *Social, Interested, Multi-Linear conformant (MLC), Parents-No English, Better than frosh, 2ndS>1stS, Trouble@Home, Remote access, Confidence, Family-focused*

Note: The student ID – Stu – gender - Multi-Active rating – STEM GPA ranking among participants

Table I-12 Multi-Active assessment and Academic profile – No. 12 Ranking Participant

Student ID	Fall Grade %	Spring Grade %	Year-long Average	Year-long trend	Multi-Active Score (max=11)	AREA154 vs. other core subjects (2nd Sem)
STU-F-7-12	72.7	91.6	82.1	1QF D 2QF D- FSG C- 1QS A+ 2QS A- SSG A-	8	STEM A- Math A English C History B- Previous STEM Grade (Freshman) C- Took STEM course following year Yes

	In-class Login % over course year	Login % at home over course year
AREA154 backend log-in frequency: (Data extrapolated based on usage across a one month time frame using "Simple History" WordPress backend plug-in.)	75%	39%
AREA154 Daily log-in duration: (Data extrapolated based on usage across a one month time frame using "Simple History" WordPress backend plug-in.)	51 min	17 min

Memos on participant's in-class behaviors: This subject was unusually quiet when compared to her female peers in the room. She was easy to look over as she did not participate in open class discussions. If she had questions that were few to none in the first semester. There was no data regarding her stand-0ffish behavior. Judging by her first semester grades (not shown, as she displayed an anomalous behavior, her first semester grades were acquired) she appeared to have something going on at school or at home that seemed to decimate her ability to do work at school. Her ATN was usually in good order and indicative of someone who paid attention to directions (second semester), though it was unclear what was the source of the disturbance. Upon consulting the site backend data, subject never "survived" any of the Examulations. This could have been do to some issues with English, as I often found it necessary to repeat or restate information to make sure she understood the information at hand. The fact that she seemed to struggle with English sometimes could indicate that no one speaks it at home. It could also be that people who are under lots of emotional trauma have very limited short-term memories and cognitive process abilities. That could also explain her need to have things re-explained. *(Observations recalled from 2018-2019 school year – 9 months of class time.)*

Memos from interview & observations: Subject was more open and verbose than when she was enrolled in AREA154. She appeared genuine with her answers, though they were vague and lacked the sort of detail that one might know if they really did remember as much as they claim they did. She was very enthusiastic about the content and being interested in what was going on. However, her responses indicate that she may have "felt" she learned a lot emotionally, but when asked to articulate specifics, the details were very sparse. She also noted that during the Examulations she would not interact with the others in the group she felt that she did the work and did not want to share information when they did not earn it nor have anything to trade in return for her assistance during this "group" test. (*Interview time: 53 min*)

Codes: Non-s*ocial, Interested, Multi-Linear conformant (MLC), Parents-NoEnglish(?), Trouble@Home, Better than frosh, 2ndS>1stS, 2ndSemResurgence, Confidence, Family focused, Social*

Note: The student ID – Stu – gender - Multi-Active rating – STEM GPA ranking among participants

Table I-13 Multi-Active assessment and Academic profile – No. 13 Ranking Participant

Student ID	Fall Grade %	Spring Grade %	Year-long Average	Year-long trend		Multi-Active Score (max=11)	AREA154 vs. other core subjects (2nd Sem)	
STU-F-7-13	91.1	72.8	82.0	1QF	A	7	STEM	C
				2QF	A-		Math	D-
				FSG	A-		English	A
				1QS	C		History	C
				2QS	C			
				SSG	C		Previous STEM Grade (Freshman)	A
							Took STEM course following year	No****

AREA154 backend log-in frequency: (Data extrapolated based on usage across a one month time frame using "Simple History" WordPress backend plug-in.)	In-class Login % over course year	Login % at home over course year
	UNK	UNK
AREA154 Daily log-in duration: (Data extrapolated based on usage across a one month time frame using "Simple History" WordPress backend plug-in.)	UNK min	UNK min

Memos on participant's in-class behaviors: The subject demonstrated some real potential cognitively. She was not only fluent in Spanish, truly seemed to enjoy her Hispanic roots, but had near-perfect Linear-Active integration socially. She was an achiever and been used to being the "teacher's pet," as she would put it. She came into the school three weeks late and was acclimated as quickly as possible. Frankly, in 25 years of teaching, never has a student become so seemingly comfortable with her surroundings as she did. She displayed a high degree of comfort within the AREA154 environment. She enjoyed the topics and the intellectual challenge it posed to her. She liked to argue; it was fun for her. Not aggressively, but more like cognitive gymnastics. After spending many lunches in the AREA154 classroom with other students, she devolved that she had been "relocated" by her father from central California to live at her aunt's house in San Jacinto, over a weekend trip. Her and her little brother had to leave everything they owned behind. According to the subject, they would be able to get their stuff sent down later. She was never given a reason. Across many discussions with her, the details appeared to be very questionable surrounding her father's "means of income." One could only speculate the sort of environment she was in on a daily basis. On her last day of school, she simply said I have to go. My father said I could come and say good-bye to anyone I wanted to. She deleted her AREA154 student account (losing all of the backend data.) I have been in email contact with her off and on over the last semester. She agreed to talk about her experiences with the AREA154 program. However, she couldn't be recorded or be on camera. The questions were sent to her, and she sent back a

written document containing information used in lieu of the interview. *(Observations recalled from 2019-2020 school year – 8 months of class time.)*
Memos from interview & observations: Not a recorded interview, rather subject requested to not be on video or audio or be recorded. She was willing to share her thoughts in a written response. The document was coherent and well written. She did from time to time say that she loved to write – as demonstrated by her A in English. She did note that her experience in AREA154 was exceptional and beyond any learning experience she had ever had. She noted herself as "not a science-minded person"; however, due to the non-traditional nature of the class, she found it to be quite beneficial. (*Interview time: 0 min*)
Codes: *Attentive-focused, Interested, Multi-Linear conformant (MLC), Trouble@Home, Positive Psycho-social integration (+PPI), Family-focused, Respectful, Atypical, Seemingly-Intelligent, Mentor, Social*

Note: The student ID – Stu – gender - Multi-Active rating – STEM GPA ranking among participants
****Left school district for undisclosed reasons. Current schedule is unknown.

Table I-14 Multi-Active assessment and Academic profile – No. 14 Ranking Participant

Student ID	Fall Grade %	Spring Grade %	Year-long Average	Year-long trend		Multi-Active Score (max=11)	AREA154 vs. other core subjects (2nd Sem)	
STU-M-7-14	72.1	91.4	81.8	1QF	D+	7	STEM	A-
				2QF	C-		Math	A
				FSG	C-		English	B
				1QS	A+		History	B-
				2QS	A-			
				SSG	A-		Previous STEM Grade (Freshman)	D
							Took STEM course following year	Yes

	In-class Login % over course year	Login % at home over course year
AREA154 backend log-in frequency: (Data extrapolated based on usage across a one month time frame using "Simple History" WordPress backend plug-in.)	47% (1st sem = 21% 2nd sem = 79%)	35%
AREA154 Daily log-in duration: (Data extrapolated based on usage across a one month time frame using "Simple History" WordPress backend plug-in.)	45 min (1st sem = 38 min 2nd sem = 52 min)	10 min

Memos on participant's in-class behaviors: The subject is highly subject to motivation via his personal interests. If he isn't interested in the class or assignment, the work automatically is placed as a very low priority. In class subject demonstrated high levels of curiosity beyond the average student. Despite his curious nature and solid questioning abilities, he did not respond to his potential until the beginning of the second term at the beginning of the Alien invasion unit. After that, he demonstrated a completely different set of academic priorities. *(Observations recalled from 2019-2020 school year – 9 months of class time.)*
Memos from interview & observations: Subject demonstrated significant interest in music and made note that while they were very interested in the class, they were not so motivated to do the "work" part of school Subject appeared to be very interested in following "fun" things after school. He said "partying" and such. Typically, when

the students would refer to these sorts of activities, it was a subtle way to convey a collection of people getting high together. This assertion is unconfirmed. However, anecdotal evidence would seem to suggest this to be true. During the interview, he noted that after fir first semester the Alien invasion case file caught his attention in a way that the other case files had not (for reasons that are not clear). At that point, he refocused his efforts and appeared to improve his level of success dramatically. Subject demonstrates behaviors more like that of a philosopher and tends to want to learn things because his curiosity has been peaked rather than being motivated by the productivity of getting things done. (*Interview time: 61 min*)

Codes: *Highly social, Interested, Multi-Linear conformant (MLC), Trouble@Home(?), Better than frosh, Emotional gratification, 2ndS>1stS, 2ndSemResurgence, Family focused*

Note: The student ID – Stu – gender - Multi-Active rating – STEM GPA ranking among participants

Table I-15 Multi-Active assessment and Academic profile – No. 15 Ranking Participant

Student ID	Fall Grade %	Spring Grade %	Year-long Average	Year-long trend		Multi-Active Score (max=11)	AREA154 vs. other core subjects (2nd Sem)	
STU-M-7-15	81.1	78.6	80.6	1QF	F	9	STEM	C+
				2QF	D		Math	D-
				FSG	B-		English	D
				1QS	A		History	C
				2QS	B			
				SSG	C+		Previous STEM Grade (Freshman)	F
							Took STEM course following year	Yes

	In-class Login % over course year	Login % at home over course year
AREA154 backend log-in frequency: (Data extrapolated based on usage across a one month time frame using "Simple History" WordPress backend plug-in.)	76%	4%
AREA154 Daily log-in duration: (Data extrapolated based on usage across a one month time frame using "Simple History" WordPress backend plug-in.)	39 min (1st sem = 38 min 2nd sem = 52 min)	4 min

Memos on participant's in-class behaviors: Subject represents one of the more interesting outliers in the study. Student was unofficially ranked by the administrative team as one of the most troubled and difficult students in the school. He displayed behaviors consistent with someone who had violent oppositional defiance disorder and had been noted to get physical with anyone who pushed him. Teachers, coaches, other students, there was a general sense of unease when subject was in class. He came from a home where he lived with his mother and an in/out step-parent that (on word from one of his friends) was verbally abusive. Home was not a good place. After taking a special interest in the student, giving him responsibilities in class that centered around AREA154 content and class functions. His seat was placed near the location where I could observe him. Conversations were generally positive but short lived. I often provided him opportunities to help him with his SRTs and retake them when he got stuck. He didn't do much with his ATN – it was largely empty and disorganized. However, once his hit enough 100% on the SRTs to show up on the leaderboard, that changed the entire outlook and motivation for the class. Grades no longer

mattered. The only motivation the subject utilized was in the top 5 Agent list on the website. He took unparallel amount of pride in being in that position. He would come in at lunch and after school to work on SRTs to maintain that position. *(Observations recalled from 2018-2019 school year – 9 months of class time.)*
Memos from interview & observations: Subject was removed from school during his Senior year and transferred to a continuation school. The interview was done over the phone rather than Zoom. Subject appeared to be hardened by life. He had a noticeable number of tattoos and no longer played baseball (a passion of his while enrolled in AREA154). Life appears to not have been any easier for him. He recalled his intense drive to be on the leaderboard. Though he could not remember much of what he learned specifically, he felt that it was the class that he learned the most. He was specifically curious about the Alien invasion case file and brought up several current events ask if I had also seen them in the news. He talked a little about why he never did work at home. No specific details were provided about exactly what aversions existed other than he tried to avoid the place. He also mentioned that he felt chilled out as an adult and felt that he could work better with people. I am wondering if that was a side effect of the THC he was routinely ingesting (he would talk about getting high after school and how it help him stay calm. I do not think he knows I overheard that conversation. Throughout the call, subject maintained that he felt he learned a lot, though didn't appear that he could recall any specific details relating to the course curriculum. (*Interview time: 56 min*)
Codes: *Highly social, Interested, High Multi-Linear conformant (MLC), Trouble@Home(?), Better than frosh, Emotional gratification, Gamification, Mentor, Confidence, Atypical, Feelings-based-Logic, Family-Focused, User, Feelings-based-Logic, Top-Grade*

Note: The student ID – Stu – gender - Multi-Active rating – STEM GPA ranking among participants

Table I-16 Multi-Active assessment and Academic profile – No. 16 Ranking Participant

Student ID	Fall Grade %	Spring Grade %	Year-long Average	Year-long trend		Multi-Active Score (max=11)	AREA154 vs. other core subjects (2nd Sem)	
STU-M-8-16	80.5	62.3	71.4	1QF	A	9	STEM	D-
				2QF	B-		Math	C-
				FSG	B-		English	C
				1QS	C		History	D
				2QS	D			
				SSG	D-		Previous STEM Grade (Freshman)	B
							Took STEM course following year	Yes

	In-class Login % over course year	Login % at home over course year
AREA154 backend log-in frequency: (Data extrapolated based on usage across a one month time frame using "Simple History" WordPress backend plug-in.)	86%	7%
AREA154 Daily log-in duration: (Data extrapolated based on usage across a one month time frame using "Simple History" WordPress backend plug-in.)	26 min (1st sem = 22 min 2nd sem = 31 min)	3 min

Memos on participant's in-class behaviors: Subject was highly social and yearned for the attention and interaction from his peers. He was curious and had the potential to be a very powerful student; however, his drive to engage in emotionally gratifying activities such as socialization, phone communication (people outside of class), and game apps, got in the way. Subject would come back to class after school, lunch, before school to ask questions and converse about all sorts of topics. Many centered around AREA154 content. Others were more hypothetical. He demonstrated many of the physiological symptoms of someone with ADHD. The topic of his attention span never came up and, as a result, never addressed. He spent time lamenting the Top Agent Leaderboard, often saying, "I guess I don't have what it takes." This was not an uncommon feeling about the Leaderboard. Other subjects noted that it was motivating to get up on it but demotivating to be pulled off of it. *(Observations recalled from 2018-2019 school year – 9 months of class time.)*	
Memos from interview & observations: During the interview I recalled that David had some pretty intense personal issues during that second semester. Perhaps he was on a downhill spiral all year. He stated he didn't even recall the A-invasion and that's the case file everyone remembers. He had a girlfriend (social issue) that was a big problem. Admittedly he stated that he was not in good shape. I recall him asking me for time to leave class and just walk the halls to cool off. I don't think his assessed grade here is a true evaluation of his potential. He achieved a B in the science class the following year. Additionally, some of his answers seem to contradict himself in terms of how he would search for information. He stated that he would usually find it on his own. However, in the interview, he stated that he would frequently come to the teacher or seek out peers to acquire information. I have a feeling this means "can I copy your work so I can get the signature on the ATN" He is a highly emotional and sensitive person. He displayed evidence that he struggles with how he feels about his actions and levels of personal success. Noteworthy observation, subject said on multiple occasions "Well, if I'm going to be honest, …" and then would answer the interview question in a way that felt incongruent with my observational experience with him. Like others he noted the class as his favorite in high school and that he learned far more in this class than any other STEM-related course. However, the depth of his answers didn't seem to indicate that he retained much of that knowledge. He does, though, clearly recall how the class made him feel. (*Interview time: 56 min*)	
Codes: *Highly social, Interested, Multi-Linear conformant (MLC), Trouble@Home(?), Better than frosh, Emotional gratification, (-)Gamification, Mentor, confidence, Family focused, Feelings-based-Logic, TopGrade*	

Note: The student ID – Stu – gender - Multi-Active rating – STEM GPA ranking among participants

Table I-17 Multi-Active assessment and Academic profile – No. 17 Ranking Participant

Student ID	Fall Grade %	Spring Grade %	Year-long Average	Year-long trend		Multi-Active Score (max=11)	AREA154 vs. other core subjects (2nd Sem)	
STU-M-7-17	58.2	82.8	70.5	1QF	C-	7	STEM	B
				2QF	D		Math	D
				FSG	F		English	D+
				1QS	A+		History	D-
				2QS	B+			
				SSG	B-		Previous STEM Grade (Freshman)	D-
							Took STEM course following year	Yes

AREA154 backend log-in frequency:	In-class Login % over course year	Login % at home over course year
	65% (1st sem = 45% 2nd sem = 85%)	9%

(Data extrapolated based on usage across a one month time frame using "Simple History" WordPress backend plug-in.)		
AREA154 Daily log-in duration: (Data extrapolated based on usage across a one month time frame using "Simple History" WordPress backend plug-in.)	40 min (1st sem = 29 min 2nd sem = 50 min)	9 min
Memos on participant's in-class behaviors: Subject displayed interesting behaviors during the course of the year. His tendency was to try and move off into a less occupied area of the room and be unnoticed. As he did participate in class discussions and would occasionally not attend his third-period class because he wanted to hear the AREA154 presentation again. Upon reviewing his Aeries records subject's scores are rather solid in the ATN. However, his performances in the Examulations appear to have been his downfall. He had a complete set of notes (or so it would seem) yet still managed to do terribly on the Examulations. He tends to exude a sort of "I know more than you" air about him. It is unknown if he actually worked with others or he was the one being shunned by the other members of the Examulation team. *(Observations recalled from 2018-2019 school year – 9 months of class time.)*		
Memos from interview & observations: Interview lasted a little more than an hour and provided some interesting anomalous behaviors. Subject did not display the traditional academic profile. He only engages in subjects he personally finds interesting or challenging. His parents work night shifts and do not appear to be largely enrolled in his academic behaviors. Subject retained his notebook (displayed it on camera – no other student was able to produce it or even offered to do so) and demonstrated on camera the notes he had completed it. He also noted that he would frequently use the AREA154 site on his phone - citing one (possibly more) time where he was in the parking lot of Walmart in the car waiting for his mom working on AREA154 content. After some consideration, a new realization arose. This was a student that has little regard for grades sitting unattended in a car. He could have his choice to do or play anything. Instead, he chose to work on AREA154 content and challenges. It should also be noted that he went on to talk about the "electronics case file" and how he continued to work with it and learn it after school was out. Very few other students mentioned this action. (*Interview time: 68 min*)		
Codes: *Non-social, Interested, Multi-Linear conformant (MLC), Trouble@Home(?), Better than frosh, Emotional gratification, RemoteAccess, Extra-effort, Emotional gratification, Top grade, 2ndS>1stS, 2ndSemResurgence, Confidence, Family focused, Feelings-based-Logic, Top-Grade*		

Note: The student ID – Stu – gender - Multi-Active rating – STEM GPA ranking among participants

Table I-18 Multi-Active assessment and Academic profile – No. 18 Ranking Participant

Student ID	Fall Grade %	Spring Grade %	Year-long Average	Year-long trend	Multi-Active Score (max=11)	AREA154 vs. other core subjects (2nd Sem)
STU-F-9-18	60.8	74.6	67.7	1QF F 2QF F FSG D- 1QS B 2QS F SSG C	9	STEM C Math C+ English D History D- Previous STEM Grade (Freshman) D Took STEM course following year Yes

	In-class Login % over course year	Login % at home over course year
AREA154 backend log-in frequency: (Data extrapolated based on usage across a one month time frame using "Simple History" WordPress backend plug-in.)	55%	5%
AREA154 Daily log-in duration: (Data extrapolated based on usage across a one month time frame using "Simple History" WordPress backend plug-in.)	17 min	1 min

Memos on participant's in-class behaviors: Subject has a very small footprint in class. Quiet but social, she made it look like she may have been doing something productive while at the same time being engaged in activities (socialization with table team, phone, apps…). When encouraged to get back to work, she would comply for the time being. However, she would then go right back to what could be considered emotionally gratifying activities. The number of interactions with this subject was limited, as she never appeared to need help and would always appear very confident that things were under control. Aeries scores indicate that she "died" in every Examulation (approx. the 7-10 month mark). This usually indicates someone who is smart enough to do the work and remembers enough to cover some distance, but not nearly enough to save herself, nor did anyone else at the table feel it necessary to assist. *(Observations recalled from 2019-2020 school year – 9 months of class time.)*

Memos from interview & observations: A pleasant person and an easy interview. She appears to have matured since my last contact with her. She appears to have more direction now. She noted on several occasions that she "felt the experience" in AREA154 was good, but there was something there that felt off. Perhaps she was sharing this because emotionally, this is what she recalls. It could be that she was surprised to hear from me and that I wanted to interview HER. We did not have a lot of contact. Perhaps the shock of being chosen was motivation to paint the experience in a way that is counterintuitive to past observations, her grades, and in-class actions. She made note that she wanted to be an art therapist for kids. STEM was never really part of the plan. Oddly, she also talked at length about the content she would bring up with her mom about the class. Apparently, they would talk about the controversial topics at home at great length. Her knowledge of scientific details was very low. However, her ability to recall the narrative associated with the content was above average. It was especially impressive, considering how much I felt she was not paying attention. After viewing her grades in other subjects, it would appear that there might some relative validity to her favorable statements towards her experience. Her grade was slightly higher than the next highest grade during her second semester. Subjects Lewis rating was exceptionally high and may posit a reason why "productivity" was never really on her agenda. (*Interview time: 63 min*)

Codes: *Social, Interested(?), High Multi-Linear conformant (HMLC), Better than frosh, Emotional gratification, Top grade, 2ndS>1stS, 2ndSemResurgence, Confidence, Family-focused, Feeling-based-Logic*

Note: The student ID – Stu – gender - Multi-Active rating – STEM GPA ranking among participants

Table I-19 Multi-Active assessment and Academic profile – No. 19 Ranking Participant

Student ID	Fall Grade %	Spring Grade %	Year-long Average	Year-long trend		Multi-Active Score (max=11)	AREA154 vs. other core subjects (2nd Sem)	
STU-M-8-19	52.7	56.7	54.4	1QF	B	8	STEM	F
				2QF	F		Math	F
				FSG	F		English	D
				1QS	F		History	D
				2QS	F			
				SSG	F		Previous STEM Grade (Freshman)	C

		Took STEM course following year	Yes
AREA154 backend log-in frequency: (Data extrapolated based on usage across a one month time frame using "Simple History" WordPress backend plug-in.)	In-class Login % over course year	Login % at home over course year	
	38%	3%	
AREA154 Daily log-in duration: (Data extrapolated based on usage across a one month time frame using "Simple History" WordPress backend plug-in.)	8 min	0.5 min	

Memos on participant's in-class behaviors: Subject has a unique demeanor. He comes across as just, angry. Interactions in class usually revolved around him coming into class breaking out his school-appointed Chromebook, and begin watching cartoons or playing games. At times he would get so angry when losing his game that he would slam the computer and storm out of the room or burst out profanities. That was the overall feeling of his time in the classroom. However, it wasn't like that during the first six weeks. Subject participated and seemed genuinely interested in what was going on. Then, something changed. His attendance records were consulted, and starting the 10th of October, each week has at least one unexcused absence and anywhere between two-three tardy notifications. Starting the Spring semester, the unexcused absences grew. He was regularly marked absent from two-five classes two-four times a week. Looking back on the experience, he was either physically or mentally not present in that room. It could be assumed that he was either unwilling to participate or unable to participate – as such the majority of his actions in class centered around emotionally gratifying activities, with rare occasions where he would be involved enough with the discussion that he contributed something unique and meaningful to the open conversation. It was rare, but it happened. *(Observations recalled from 2019-2020 school year – 9 months of class time.)*

Memos from interview & observations: Again, the enigma arises. Twice during the interview, he stated that "your class was one of my favorites". It is unclear why that statement was made. He stated that he didn't really talk to family about the class, as he was the youngest of five children and the others were away from home. He did not appear to have many conversations with his parents. He may not even spend that much time at home. At the time of the interview, he was at a friend's house who had internet access. His was apparently not working well. Subject displayed a sort of fondness for the environment. He noted during the discussion of the AREA154 system that he thought it was "cool that you made your own stuff custom". Indicating that he valued the effort the instructor made towards their experience. One might assume that this was not a shared feeling with most of his classes. He had very general recall about the casefiles referring to them as "The volcano-one" and "The alien-one". When asked about his absences and why he was gone all the time, he said there was "stuff he had to do". At that point, his friend laughed – indicating that this was not the whole story. When pressed for more details, he was very hesitant to reply. When asked if he was at school or not during those absences, he said that he was sometimes, sometimes not. I asked if that something that he needed to deal with started in October. He thought that sounded accurate. So, whatever it was that he was "stuff" he was doing has a pretty heavy impact on his ability to succeed at school. Also curious, when we spoke about his confidence level in AREA154 vs. other programs, he was animate that he felt more successful in the AREA154 program than he did in his previous STEM class (biology). Enigmatic because his grade was higher in biology than it was in this program. (*Interview time: 63 min*)

Codes: Non-s*ocial, Interested(?),Multi-Linear conformant (MLC), Emotional gratification, 2ndS>1stS, Trouble@home, Confidence, Atypical, Feeling-Based-Logic,*

Note: The student ID – Stu – gender - Multi-Active rating – STEM GPA ranking among participants

APPENDIX J

Open Coding of Student Profiles

Table J-1 Coding pass: Open coding of student profiles

Codes Used	Meaning	Frequency of Usage
2ndS>1stS	Achieved a better grade in the second term (spring).	AAAAA (5/7) BBBBBB (6/7) C (1/2) DD (2/2)
2ndSemResurgence	Demonstrated a 10% or greater increase in grade in the spring semester over the previous semester.	A BBB C D
Archiver-type	Has the ability to take exceptionally good notes, almost as if they were archiving information for posterity.	AAA (3/7) B (1/7)
Attention-focused	Is very rarely engaged in behaviors that are not the topic of focus in the class at the time.	AA (2/7) B (1/7)
Atypical	Demonstrated a notable trait or behavior that affected their AREA154 experience and is very rare among the subject pool.	AAA (3/7) B (1/7) C (1/3) D (1/2)
Better than frosh	Earned a higher grade in AREA154 than in freshman biology.	AAAAAA (6) BBBBB (5/7) CCC (3/3) D (1/2)
Confident	Displayed or overtly stated that they felt notably more confident in AREA154 than in other STEM programs.	AA (2/7) BBB (3/7) CCC (3/3) DD (2/2)
Curious *Highly curious	Demonstrated that curiosity is a driving factor in their engagement. Noted that curiosity was *the* defining motivating factor for their engagement.	AAAA* (4/7) B*B* (2/7)
Delta worldview	Has overtly shown significant evidence that their worldview has changed due to their AREA154 experience.	A (1/7)
Disciplined	Displayed notable levels of self-discipline.	AAA (3/7)
Emotional gratification	Participated in emotionally gratifying activities at a notable rate.	AA (2/7) BBBB (4/7) CCC (2/3)

(~) Emotional gratification	Engaged in emotionally gratifying activities occasionally. (*Such activities are defined as game apps, social media, texting, online games, YouTube, or anything that is a non-thinking activity designed to raise serotonin levels.*)	D (1/2)
Exo-managed	Behavior is managed by an external influence from outside the family, like clubs, organizations, or sports.	A (2/7)
Extra-effort	Engaged in the AREA154 program on their own time doing content-related work inspired by the program.	A (1/7) C (1/3)
Family-focused	Has noted that they put family first, then school or career.	AAAAA (5/7) BBBBB (5/7) CCC (3/3) DD (2/2)
Family-sharing	Shares AREA154 learning content (scientific or narrative) with a family member.	A (1/7) BB (2/7)
Feeling-based logic	Demonstrated a propensity to make decisions almost entirely based on how a certain event or task made them feel.	A (1/7) CCC (3/3) DD (2/2)
Gamification	Was positively affected by the gamification enough to mention it during the interview.	A (1/7) BB (2/7)
(-) Gamification	Demonstrated de-motivating behaviors due to the gamification elements.	CC (2/3)
Grade-motivated	Indicated that grades are their primary motivation for success in school.	AA (2/7)
Interested	Demonstrated interest in the AREA154 program as the motivation for participating in class.	A (1/7) BBB (3/7) CCC (3/3) D (1/2)
Mentor	Received additional guidance from the instructor beyond the confines of the normal class day on a routine basis (after school, at lunch, before school).	B (1/7) CC (2/3)
Minimalist	Demonstrated in class or noted in the interview that they do the absolute minimum to meet the requirements of the task at hand.	A (1/7) D (1/2)

Mom-managed	Has overtly stated or shown evidence of having a mother who has a significant role in managing the student's academic career.	A (1/7)
Multi-linear conforming (MLC) High multi-linear conforming (HMLC) (~) Multi-linear conforming [(~)MLC]	Has a score between 7 and 8 on the Lewis assessment. Has a score of 9 or higher on the Lewis assessment. Has a score slightly higher than 50% on the Lewis assessment.	AAAAA*A (6/7) BBBBBBB* (7/7) CCC* (3/3) DD* (2/2)
Non-social	Demonstrates a tendency to not talk in class. Is introverted and tends not to speak out in class.	A (1/7) B (1/7) C (1/2)
Parents-no-English	Indicated that both parents do not speak English.	A (1/7) BBB (3/7)
(+) Psycho-social integration (+PPI) *Forced (+) psycho-social integration (F+PPI)	Displayed significant skills in integrating into the linear-active social behavioral system (playing the game of school). Was indoctrinated through some official program to learn how to be linear-active. This is likely due to membership in ROTC, AVID, or extensive parental management.	AAAAA* (5/7) B (1/7)
Remote-access	Accessed the temple.area154.net website away from home and away from school.	A (1/7) B (1/7) C (1/3)
Respectful	Exhibited notable levels of respect during class.	AAAA (4/7) B (1/7)
ROTC	Belonged to the Air Force ROTC at San Jacinto High School.	AA (2/7)
Routine-centered	Stated or demonstrated that they base their day or actions around a strict routine.	AA (2/7)
Science-minded	Stated during the interview or through actions in class that they are looking for a career in science or a related field.	A (1/7)
Sister-mom	Specifically noted having mom-like responsibilities at home—responsibility over siblings that superseded academic obligations.	AA (2/7) B (1/7)
Social *Highly social	Demonstrated a notable amount of socialization in class.	BBB (3/7) C*C* (2/3)

	Demonstrated a much higher than normal socialization rate.	D* (1/2)
Top-grade	AREA154 was the top grade on the final spring report card.	AAAA (4/7) BB (2/7) CC (2/3) D (1/2)
2nd-top-grade	AREA154 was the second-highest grade on the spring report card.	AA (2/7) C (1/3) D (1/2)
Trouble@home	At some point during the interview, there was overt evidence to suggest that the student was experiencing discord at home.	A (1/7) BB (2/7) CCC (1/3) D (1/2)
User	Demonstrated behaviors in class or noted actions during the interview that signal they used other people to acquire work or manipulate them to bypass doing the work in the program.	A (1/7) C (1/3)

Note: Several codes had been removed from the list due to lack of frequency or lack of relevance to the topic under study.

APPENDIX K

Code frequency analysis – Participant Achievement

Interesting trends began to take shape when the codes were collected and code frequency was analyzed. The codes that resulted from the grade analysis, the observational summary, and the interview were posted at the bottom of each subject's profile. The accumulated codes present the student's experiences and personal representation both as a student and as someone who has experienced an entire academic year in a uLearning system. As the analysis continued, more of the same codes arose, demonstrating patterns among different academic achievement levels. The analysis includes the percentage of login frequency while in school and the percentage of login frequency by the same user during the same day but outside the school network. The assumption is that these logins are taking place either at home or on the go. Few of the subjects commented on using anything but their school-supplied Chromebook for accessing the site. Thus, the assumption that the logins are taking place at home could be considered a sound presumption. The frequency was determined by the number of logins between a specific range of dates. In this case, the frequency was measured across the fall semester of 2019, divided by the total number of school days during that period. The formula is as follows:

$$\textit{Average login frequency} = \textit{(No. of logins/total school days)}$$

Table K-1 presents the results from the segregation of codes by academic achievement level and backend login information on the AREA154 site.

Table K-1 Code frequency results by achievement level and login data

Course Grade	Code	Frequency	Login Freq. @School	Login Freq. @Home
Students with A	Multi-active-conforming*	7/7	Ave: 90.4%	Ave: 54%
Year-long average	Better than frosh	6/7	T_s = 43 min	T_s = 24 min
Subjects = 7	2ndSem>1stSem	5/7		
	Social	5/7		
	Family-focused	5/7		
	Emotional-gratification	5/7		
	(+) Psycho-social integration	5/7		
	Atypical	3/7		
	Achiever-type	3/7		
Subjects with B	Better than frosh	7/7	Ave: 71%	Ave: 28%
Year-long average	Top grade	6/7	T_s = 42 min	T_s = 13 min
Subjects = 7	2ndSem>1stSem	6/7		
	Family-focused	6/7		
	Multi-active-conforming*	6/7		
	Social	5/7		
	Respectful	5/7		
	Parents-no-English	3/7		
	Confidence	3/7		
	Interest	3/7		
	2ndSem-resurgence	3/7		
	(+) Psycho-social integration	1/7		
Subjects with C	Top grade	3/3	Ave: 76%	Ave: 6%
Year-long average	Better than frosh	3/3	T_s = 30 min	T_s = 5 min
Subjects = 3	Interest-driven	3/3		
	Family-focused	3/3		
	Emotional-gratification	3/3		
	Feelings-based-logic	3/3		
	Multi-active-conforming*	3/3		
	Trouble@home	2/3		
	Social	2/3		
	Mentor	2/3		
	Parents-no-English	1/3		
	User	1/3		
	Remote-access	1/3		
	Non-social	1/3		
	Atypical	1/3		

*This data resulted from a questionnaire developed explicitly from Lewis' (2012) descriptions of multi-active and linear-active psycho-social behaviors. Questions were modeled as a scenario wherein two options were provided. The subject would choose between the two options based on what they believed they would do in the given situation. One option was derived from the multi-active behavior list, and the other was derived from the linear-active behavior list.

Table K-1 tabulates the codes that resulted from the dynamic analysis of the uLearning system's users. As noted before, the subjects were selected from a wide range of achievement levels. Students from every grade (A–F) were solicited via email to participate. There is a heavier representation of A and B grades than C or D/F grades. One could argue that this makes sense given the nature of the students who are likely to respond to teachers, emails, and requests and those who are less likely to do so. One might posit that if the C or D/F students were more responsive to their school email and teacher requests, they would probably be A or B students. In any case, the data collected by the individuals who did respond to the interview request is presented below, showing the findings of code frequencies broken down by achievement level.