CULTIVATING GENIUS: AN EXPLORATORY CASE STUDY OF THE GENIUS HOUR INSTRUCTIONAL TECHNIQUE AND ITS EFFECT ON THE IDENTITY AND SELF-EFFICACY OF HIGH SCHOOL SCIENCE STUDENTS

by

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DEDICATION

Genius Hour is a technique that embodies asking questions. This dissertation is dedicated to all of my students who asked tough questions of me and consistently inspired me with their enthusiasm for learning.

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ABSTRACT

Genius Hour, a project-based instructional technique that promotes learner autonomy, has developed a dedicated following among teachers. However, despite the widespread enthusiasm about Genius Hour in the K-12 classroom, little to no empirical evidence exists on the effectiveness of the approach. To respond to this gap in the research, a longitudinal exploratory case study was implemented to better understand the practices of Genius Hour in a high school STEM environment.

Of particular interest for this investigation was the influence of Genius Hour on students' identities and self-efficacy and in particular, on science identity and science self-efficacy. A two-year, longitudinal, mixed methods, exploratory case study spanning two years was performed that focused on high school freshmen (n=136) and their participating classroom teacher. Data sources included self-report surveys regarding identity and self-efficacy, as well as whole group interviews, individual interviews and small group interviews. Quantative data was analyzed using a paired t-test and normalized gains and effect size, while qualitative data was analyzed using emergent thematic analysis. Quantitative measures indicated the Genius Hour instructional technique increased students' belief in their scientific ability based on pre and post survey data, however, the effect size was small. Additionally, students had statistically significant gains in the Next Generation Science Standards Science and Engineering Practices (National Research Council, 2016) of *asking questions and defining problems* and *analyzing and interpreting data*. While quantitative analyses did not yield any significant results to suggest influence of Genius Hour on identity, there were substantial qualitative results to suggest participation in Genius Hour developed students' identities and in particular, their science identities.

INTRODUCTION

It has been suggested that the industrial model of education has traditionally valued uniformity of speed, where all students progress through the system at the same rate and technique and where the same instruction is used for every student (Robinson, 2007). Systemic quality control mechanisms such as standardized tests, promote conceptual uniformity where all students have the same knowledge core are often the norm in these contexts. However, standardized tests often fail to identify critical skills, such as creativity and problem solving, which are essential in the global workforce (Robinson, 2010). Therefore, it would seem contradictory for schools to work toward developing homogenized student batches through aggressive standardization of content and delivery, at a time when workplaces are seeking independent workers (Grinberg, 2014).

Large corporations that thrive on innovation, such as IBM and Google, routinely explore strategies and environments that encourage independent and creative thinking in their employees. In some circumstances these companies are allowing their employees to focus 20% of the work week for personal innovation projects that further the company's goals and objectives (Grinberg, 2014). In these contexts, workers are driven by passion, purpose and intrinsic motivation. Given opportunities that leverage autonomy to showcase unique vision and talents, workers created products while simultaneously developing their individual corporate identity and defining their role in a complex organization (Grinberg, 2014). The freedom to explore personal interests is noteworthy, as research indicates that a strong alignment between one's identity and the work one is

called to do can result in increased engagement, fulfillment and investment (Aschbacher, 2009). Identity is an incredibly complex concept which will be discussed and defined at length in Chapter Two.

In response to these workplace innovations, Pink (2011) challenged schools to apply this new culture to school contexts. Subsequently, educators have been exploring mechanisms for integrating these same workplace innovations into K-12 environments (Juliani, 2014). Although many models exist for supporting this new notion of creativity and autonomy, Genius Hour is one such innovation being widely applied across diverse educational contexts (Juliani, 2014). Genius Hour is a project-based educational technique based on Google's 20% Time, and has been conceptualized as a mechanism to infuse school contests with this cultural autonomy fueled by passion, purpose and intrinsic motivation (Juliani, 2014). During 20% Time workers are given the opportunity to align their personal purpose, interests and skills with projects they think will further the company and some of Google's best innovations are these 'pet projects' created during this time period (Juliani, 2014). Applying this same approach to education affords students radical autonomy and challenges them to bring their interests and passions to life and share them with the community by providing 20% educational time for project development (Juliani, 2014).

Significance of the Study

Although a very limited body of research currently exists on Genius Hour, anecdotal evidence, coupled with practioner-level findings suggests that it is an

instructional technique that may promote identity development, innovation and self efficacy. These skills act as a core to which all other skills can be connected (Brophy, 2004). For example, when students have a strong identity and self-awareness they are more likely to be personally invested in learning (Kesler, 2014). This personal investment is often expressed as a strong authorial voice in their student work, willingness to take chances and increased self-confidence (Kantier, 2009). Further, when students can be experimental in their learning, there is an increased opportunity for growth. The skills of an established identity and strong self efficacy, not only cross all disciplines, but contexts as well and form the crux of self-actualization (Maslow, 1943). Better understanding of the influence of Genius Hour on teaching and learning could serve as a catalyst to infuse K-12 education with the mechanisms to encourage identity development, innovation and self-efficacy.

Genius Hour is being applied to all grade levels and content areas (Juliani, 2014). One area in particular where Genius Hour is gaining considerable attention is STEM fields. This increased attention on Genius Hour might be attributed to the notion that the true nature of science and innovation is situated on the bedrock of creativity (UC Berkeley, 2015). In scientific endeavours, scientists use divergent thinking, a type of creative thinking that sees multiple possibilities in a given context, to solve a problem (Robinson, 2007). The autonomous, inquiry-like investigations that take place during Genius Hour may be more representative of the real process of scientific investigation than more teacher-led instructional strategies (Juliani, 2014).

Genius Hour, as often implemented in science instruction, has students doing science about which they are passionate and where they investigate a personal passion through a scientific lens (Krebs & Kirr, 2014). Other research suggests that Genius Hour may also contribute to science identity formation and increased science self-efficacy by linking individual interests and talents to the field of science (Aschbacher, 2009). Interests and talents are established components of an individual's identity and are generally considered 'areas of expertise' (Aschbacher, 2009).

More importantly, Genius Hour efforts seemingly align with calls from the National Research Council, which has identified a research gap in the area of science identity formation (Riedinger, 2015). Considering Genius Hour has been defined as a teaching technique where students create radically autonomous passion projects that are shared digitally with the community (Juliani, 2014), Genius Hour could serve as a critical vehicle to promote science identity formation. Authentic science experiences coupled with positive reinforcement of science work and interaction in a science community are contributing factors to the construction of students' science identity (Aschbacher, 2009). Genius Hour, as implemented in a science class, has students doing science about which they are passionate. Linking individual interests and talents, which are established components of an individual's identity, to science, may foster the integration of science into the students' identity and a stronger belief in their ability to do science (Colley, 2008). Subsequently, the formation of a science identity may lead to an increased capacity for students to perform scientific thinking in their day-to –day tasks or may lead to an affinity for STEM careers.

Problem Statement

The Genius Hour educational movement does not have a well-defined beginning, but appears to have a significant practitioner following that is active with digital media (Wettrick, 2014). The limited research on Genius Hour indicates that teachers who have implemented Genius Hour perceive an increase in higher level thinking skills of their students, more engagement and time on task, and a new found hunger for learning that spills over into all areas of instruction (Krebs & Kirr, 2014). Additionally, there are some indications that the Genius Hour process may contribute to identity formation and greater self awareness in students (Krebs & Kirr, 2014). Given the NRC's (2015) call to better understand science identity formation, gaining a better understanding of how Genius Hour may influence science identity is a prudent direction for this study. And while anecdotal data suggests that Genius Hour is being warmly received by teachers and students, there remains a lack of a formal research basis on Genius Hour. Therefore, more formalized, empirical research is needed to fully understand the influence Genius Hour might play in learning and on the development of science identity and self-efficacy.

Purpose Statement

The purpose of this exploratory case study was to explore the development of identity and self-efficacy, broadly and in the domain of science for freshman physical science students participating in Genius Hour at a high school in the Rocky Mountains. More specifically, the intent of the study was to investigate identity and self-efficacy formation through the Genius Hour process, with special attention given to the

development of science identity and self-efficacy. As stated, Genius Hour is defined as a teaching technique where students create radically autonomous passion projects that are shared digitally with the community (Kesler, 2014). It is important to note that 'radical autonomy' is the defining feature of Genius Hour, which distinguishes it from other project-based learning tasks and its importance cannot be overstated. Identity and self-efficacy were selected as a primary focus for the study because research indicates authentic science experiences, coupled with positive reinforcement of science work and interaction in a science community are contributing factors to the construction of students' science identity (Aschbacher, 2009). Further, the development of a strong science identity is positively correlated with increased science literacy (Kessels & Taconis, 2012), increased pursuit of STEM careers and increased science integration into everyday common tasks (Aschbacher, 2009). A more complete understanding of how Genius Hour can be used to build students' science identity could inform practice and research on building STEM pathways through interventions that increase learners' science identity and self-efficacy.

Research Questions

The focus of this study was on how the Genius Hour instructional technique may influence identity formation and self-efficacy. Therefore, the major research question guiding this study was: How does participation in Genius Hour influence identity and self-efficacy in high school science students? The following sub-questions, pertaining specifically to the discipline of science, were also used to structure the investigation:

How does Genius Hour develop science identity? How does Genius Hour develop science self-efficacy?

The formation of these research questions was influenced by established empirical research on identity and self-efficacy and applied to the new instructional technique of Genius Hour. Some research suggests that students perceive science as difficult, with students disproportionately reporting low self-efficacy compared to other subjects (Aschbacher, 2009). Additionally, there is considerable research suggesting a lack of interest in STEM fields may be connected to poor science identity development (Aschbacher, 2009). Students usually enjoy and persist at activities and topics they are competent at and are more likely to incorporate positive experiences into their view of self (Maiers & Sanvold, 2014). Therefore, a logical instructional strategy of pairing science, something seen as difficult by some students, with personal interests, such as skateboarding, emerged as an area of study.

For the purposes of this study, identity formation will be viewed through a post-modernist constructivist lens. Post-modernism accepts an individual's construction of reality and is highly focused on lived personal experiences and the meaning assigned to the experiences based on his or her values (Howard, 2000). For example, a student that values creativity and innovation may regard tasks, where freedom of expression is nurtured, as more meaningful learning experiences. Current research on identity formation suggests that identity is a self-construction of our experiences and the value we assign to them as well as how we integrate the feedback we receive from others (Howard, 2000). This paradigm aligns with the Genius Hour instructional technique which seeks to

encourage individual expression by providing students radical autonomy. Genius Hour also elicits students' reflection on their existing individual interests and challenges them to further their knowledge and skills in their chosen areas which align with constructivism as applied to learning (Juliani, 2014). Combined, these understandings of identity formation suggest the process of learning about 'who we are' follows a similar trajectory as constructivist learning of non-personal subject matter.

Study Overview

In this study, the influence of Genius Hour on student identity and self-efficacy was studied using mixed methods, exploratory, longitudinal case study approach. Initial data collection began prior to using the Genius Hour instructional technique on 9th grade, physical science students (n=136) in a small, affluent suburban school in the Northern Rockies. Students spent six weeks on the Genius Hour project where they researched 'the science of (their personal passion)' and created a video presentation of their work (Appendix A). Data collection occurred during the intervention and at the culmination of the Genius Hour projects. Additionally, a sub-sample of eight students was chosen to take part in a longitudinal study lasting the subsequent 24 months. Qualitative analysis included thematic analysis of individual interviews, small group interviews and written responses to survey questions, while qualitative data included students ranking their perceived science identity and self-efficacy as well as their perceived competence on the Next Generation Science Standards Science and Engineering Practices (National Research Council, 2016), pre and post Genius Hour. Quantitative data was analyzed

using paired t-tests and normalized gains (Hake, 1998). A much more thorough discussion of the data collection instruments, administration and analysis procedures is discussed in Chapter Three.

Definitions of Key Terms

In an attempt to accurately describe the Genius Hour instructional technique and the large concepts such as identity and self-efficacy, each term is defined as it relates to this study and should not be confounded by other definitions found in other educational contexts. The definitions are grouped based on natural relationships rather than alphabetical order. Each term is described more robustly in Chapter Two and developed throughout the study.

- *Genius Hour* is defined as a project-based, inquiry learning instructional technique where students are given 20% class time to work on projects that they are personally passionate about (Juliani, 2014). Additionally, the defining feature that separates Genius Hour from other project-based learning tasks is '*radical autonomy*,' whereby students are in control of their project and the way in which they communicate their learning (Juliani, 2014).
- *Autonomy* describes students having control over their content and their execution of a project and, in some cases, students may choose indicators of quality for assessment purposes (Kesler, 2014).
- '*radical autonomy'* a feature of Genius Hour where almost all of the learning decisions regarding students' projects are in their hand which is a radical departure from traditional instructional styles.

- *Authorial voices,* defined as the distinctive qualities of an individual based on their values (Aschbacher, 2009) which are fostered in environments where freedom of expression is allowed.
- *Mastery* describes the urge to get better at something that is important to the individual and competence is defined by the individual's values and personal indicators of quality, where set-backs are seen as learning opportunities and the focus of the project is on the learning journey rather than the final product (Kesler, 2014).
- *Purpose* encapsulates student self-reflection on their personal passions and their value in the real world (Kesler, 2014).
- *Operationalization*, is defined as the process of defining and describing a phenomenon with specificity (Schunk, 2012). Operationalization of the Genius Hour technique was completed prior to examining the influences of Genius Hour in a classroom setting.
- *Longitudinal* is defined as a study of the same research subjects spanning years, sometimes decades (Patton, 2001). In this study longitudinal encapsulates a two year time frame following Genius Hour.
- *exploratory case study* is defined as a context bound study that investigates phenomena for which there is a lack of preliminary research (Mills, 2010).
- *Triangulation* is defined as a research technique that assists in the validation of a study's results from two or more sources (Schunk, 2012).

- *Identity* is defined as the collection of actions and choices that are demonstrated in a given context (Erikson, 1969). Further, identity is a construct of the 'stories we tell ourselves,' (Kapur, 2009) suggesting that identity is a subjective representation of one's role in the environment based on one's values and beliefs which is dynamic and malleable. For example, an individual who values community may have an identity is defined by their role in relation to others.
- *Science identity* is defined as the extent to which one sees himself/herself as a scientist.
- *Hybrid Identity* describes an identity which is created when personal knowledge and interests merge with traditional academic knowledge (Guiterrez, 2008).
- *Third Space* is defined as a designated time and place where students are given opportunities to merge their personal knowledge and academic knowledge, thereby facilitating the formation of hybrid identities (Guiterrez, 2008).
- *Self-efficacy* is defined as an individual's perception about their ability to succeed and accomplish a task (Kaplan & Flum, 2012).
- *Science self-efficacy* is defined as a belief in one's self to accomplish scientific tasks.
- *Science and Engineering Practices* are described as a set of knowledge and skills students require to be able to do science, reframing science as a verb instead of solely a body of knowledge to be memorized (National Research Council, 2016).

Study Limitations

The major limitation of this study is that it is focused on an innovative educational intervention, Genius Hour, for which there is no established research basis. This means there is an absence of formalized research protocols to use as a framework to guide this investigation. While there is substantial anecdotal evidence suggesting themes and providing general descriptions of the phenomenon, there is limited understanding of how Genius Hour works or how it influences student identity and self-efficacy. Another limitation is that the study investigated identity; identity is influenced by many factors over the lifetime of a child and while this complex construction may be affected by educational interventions (Erikson, 1969; Dewey, 1910), it is difficult to isolate the influence of these interventions and make definitive claims about the development of certain traits in direct response to Genius Hour. However, the longitudinal component of the study coupled with continued interviewing increased the reliability of the claims as the researcher could compare the students' individual narratives over time to describe the steadfastness of students' description of the Genius Hour phenomenon and account for lasting changes in behaviour.

A third limitation of the study is that it relies on self-reported data. More specifically, self-report instruments were used in this study which cannot be independently verified. Possible biases present in the data could be *selective memory* of the participants in which they remembered certain events and disregarded others, *attribution*, in which the students may have cited their own success with Genius Hour to their own personal agency and aptitude versus the external technique and *exaggeration*

where the students could have possibly embellished the significance of their Genius Hour project. To mitigate this limitation, students reviewed their previous responses to ensure they were fair, accurate and a true representation of their experiences. While selective memory, attribution and exaggeration are all legitimate study concerns, when one considers the topic of identity formation, they may not be significant. If identity is based on the stories we tell ourselves and the meaning we make from events based on personal values (Howard, 2000), an objective construction of reality may provide little worth. The students' personal construction of their identity which is based on their interpretation of reality, however flawed, is the construction of 'who they are' that is most likely to be carried forward (Howard, 2000). If a student believes they are creative and innovative from participating in Genius Hour, even though their initial project may not demonstrate mastery in these areas and they subsequently take chances on future projects, the hard skills may eventually develop from their belief in their ability to succeed.

A fourth limitation of this study may be the sample size of the sub-sample chosen for the longitudinal study. The original sample size of eight students decreased to three students by the end of the two year study due to factors of attrition. However, the three students that remained in the sub-sample were present for every data collection and provided in depth responses regarding their Genius Hour experiences.

Study Delimitations

A delimitation of the study is that it was conducted as an exploratory case study bound in the context of a single high school in the Northern Rockies. This research

choice was made to allow the researcher to focus on the depth of individual student experiences during Genius Hour instead of the breadth of experiences that would likely exist with a more diverse and expansive population. Depth of individual experience aligns with the Genius Hour instructional technique which values the personal learning experience of each student as well as the post-modernist values in which Genius Hour is rooted. Additionally, the selection of an eight student sub-sample to participate in the longitudinal aspect of the study was performed to allow for the expression of individual narratives versus the establishment of a collective voice that is attainable with greater trustworthiness in studies with a larger sample size. A predominantly qualitative approach was used to capture the richness of individual student experiences and while quantitative data was used in triangulation, the greater emphasis on qualitative data may limit the generalizability of the claims of the study.

Another possible delimitation of the study is that the longitudinal portion of the study obtained data for 24 months after the Genius Hour intervention. While the researcher will continue to follow the sub-sample of students (n=3-8) and obtain data throughout their post-secondary years, the claims made in this study may be strengthened or weakened by subsequent findings. However, because the subjects of this study were in high school at the time of this publication, many had already solidified their plans for post-secondary which were discussed in relation to Genius Hour in Chapter Four.

Summary of Chapter One

Chapter One described some of the global trends taking place in education in response to changing demands in the workplace and highlighted the post-modernist cultural values of individualtiy, creativity and innovation. The shifting cultural paradigm has challenged educators to experiment with new educational techniques, such as Genius Hour, to cultivate these skills in students. A brief description of the anecdotal evidence on the Genius Hour technique and how it may contribute to identity and self-efficacy was briefly discussed. A more thorough summary of these observations is described in Chapter Four as this study sought to operationalize the Genius Hour technique through thematic analysis of educator and student descriptions of the phenomenon. Additionally, a general study plan was outlined, which established the founding principles for the choice of a predominantly qualitative, longitudinal study and alignment with the Genius Hour values and the post-modernist paradigm. A more thorough description of the implementation of this educational intervention and the instruments used to study the effect of Genius Hour on identity and self-efficacy is found in Chapter Three.

CONCEPTUAL FRAMEWORK

Overview

This study examined how Genius Hour broadly influenced identity and self-efficacy in students and further investigated the domain specific influence on science identity and science self efficacy. This chapter defines identity and self-efficacy and examines identity formation using Hybrid Identities Theory/ Third Space Theory (Gutierrez, 2008) and Interest Theory (Dewey, 1910). The discussion describes the vertical alignment of Dewey's Interest Theory (1910) into the concept of Hybrid Identities (Gutierrez, 2008) by suggesting that increased interest increases the time the student spends in the 'third space', a construct that merges authentic interests with academia. The theoretical framework of the Hybrid Identities Theory was selected as the main theoretical framework for this study because it suggests a mechanism for identity development and describes an environment to facilitate this development. This environment is known as the 'third space' (Guiterrez, 2008). There is considerable alignment between the 'third space' and the instructional practice of Genius Hour, where students bring their personal passions into the school environment. The strong alignment between Gutierrez's (2008) description of the 'third space' and the best practices described in books (Juliani, 2014; Kessler, 2014) and anecdotally in teacher blogs (Krebs & Kirr, 2014) made it the most suitable theory for this study and may assist situating Genius Hour, a practitioner's construct, among more formal peer-reviewed research.

Identity

What is Identity?

Based on Erikson's (1969) theories, identity is defined as the pattern of actions and choices that are demonstrated in a given context. These behaviors may shift in response to changes in context and may also shape a particular context; this interplay can be seen as a 'negotiation' which attests to the malleable nature of identity (Faircloth, 2012). Fundamental to the concept of negotiation is the agency of the individual to effect change in their surroundings (Brophy, 2004). This definition frames identity as construct that can be consciously created and does not support the notion that identity is solely a product of a given environment. Kapur (2009) defines identity as the stories we tell ourselves and goes as far as stating that "a person without a story does not exist." Kapur (2009) suggests that our stories are a living relationship between the environment, who we are and who we aspire to be. The story analogy may suggest that identity is not as much as the product of our experiences, but rather the more influential and critical factor is the authorial voice we used to describe and assign meaning to those experiences. In terms of education, student growth may be achieved by mindfulness in planning experiences, but also in influencing the students' authorial voice, or the nuanced manner in which they choose to express themselves.

These definitions of identity suggest that the construct is dynamic, as different contexts reveal different facets of identity (Erikson, 1969). Therefore, the construct of identity could be described as malleable (Kapur, 2009); if the authorial voice regarding our experiences changes, how we see ourselves may also change. Malleability is of

special interest to teachers who aim to instill not only knowledge and skills, but also attitudes and attributes in students. Dweck (2006) suggested identity is a 'work in progress', developed by resiliency and self-efficacy in challenging contexts which suggests a relationship between identity formation and self-efficacy which will be discussed in greater detail in subsequent sections. This concept extends the role of teachers from influencing what students know and can do, to who they are and who they wish to become. In summary, identity as a pattern of choices and actions that are context specific and that identity is a construct that is dynamic and malleable which makes identity an excellent topic of study as research suggests indentity could be changed by teacher actions and an instructional strategy such as Genius Hour.

How is Identity Formed?

Understanding the contextual and social influences on identity that are pertinent to the classroom environment is critical for understanding th role identity plays in learning and how its development may be fostered in the classroom. Identity formation is shaped in response to contextual influences (personal, social, cultural, situational, institutional, historical) (Faircloth, 2012). Dewey (1910) & Vygotsky (1962) theorized that identity formation was a constructivist enterprise where identity was developed through conversations with oneself and a larger community. Moll (1992), furthered Vgotsky's initial constructivist ideas by suggesting that students come into a learning situation with 'funds-of-knowledge,' developed through previous experiences. Students use their previous experiences to create narratives that foster a sense of belonging to the classroom learning community (Moje, Tucker-Raymond, Varelas, & Pappas, 2007).

Classrooms that allow students to express their indivdual narratives and voices are more likely to influence identity (Faircloth, 2012).

Marcia (1980), stated that identity formation is of particular importance to teenagers and suggests two mechanisms at work; *exploration* is defined as an active struggle where teens are questioning what they believe about their identity and a later stage of *commitment* where they have an unwavering belief in a particular narrative about themselves and existential events are evaluated in regard to these self-constructed truths. Genius Hour, with its elements of radical autonomy and expression of personal interests may be a technique to promote an environment where identity formation can occur.

Third-Space/ Hybrid Identities Theory

Hybrid Identities Theory (Gutierrez, 2008) has been included in this review of relevant literature because the theory seeks to describe and explain a learning context where there is an opportunity for integration of academic identity and personal identity. As a result, Hybrid Identities Theory (Gutierrez, 2008) strongly aligns with the central premise of the Genius Hour, given that Genius Hour is often described as an environment "where passions come to life" (Kesler, 2014). The notion of a 'third space' (Gutierrez, 2008) is a critical component of describing the role Hybrid Identities Theory plays in shaping this study's theoretical framework. The 'third space' is defined as a space that blends the traditional elements of school curriculum with personalized elements that are dear to students such as interests and hobbies (Gutierrez, 2008). The role of the teacher is to create the intersect of the third-space with the aim of hybridizing school curriculum,

often viewed as isolated knowledge, with the more emotive, personalized, and established facets of each student's identity. In Gutierrez's model (2008), the third space is created by the teacher facilitating learning opportunities where students can connect home and school dimensions, while the formation of a hybrid identity, whereby students develop academic dimensions of their identity by connecting them to established personal identity, is the aim of this instructional approach.

Guiterrez (2008) emphasized the conceptual, constructivist nature of identity formation and acknowledged the critical interplay between academia and personal values and experience. Of particular interest to educators, research suggests many 'at-risk' students from low socio-economic backgrounds have significant funds of knowledge, but traditional settings fail to draw on this resource resulting in a misrepresentation of student ability (Moje, Tucker-Raymond, Varelas, & Pappas, 2007). In such a scenario, the failure of the teacher to effectively develop the third space may be misconstrued as shortcomings of the individual students (Moje, Tucker-Raymond, Varelas, & Pappas, 2007), therefore, Genius Hour may assist at-risk students to a greater extent than students that excel in traditional classroom environments. The Hybrid Identities Theory suggests identity development must be intentional rather than a haphazard by-product of traditional curriculum design (Faircloth, 2012). Genius Hour is highly intentional in its call for reflection, on the part of the students, regarding their personal interests and overt integration of these interests into the classroom environment (Wettrick, 2014) and academic knowledge realm.

Vertical Alignment of Interest Theory and Hybrid Identities Theory

Vertical alignment is often used to describe concepts and theoretical frameworks that build upon each other. Dewey's Interest Theory (1910) vertically aligns with Hybrid Identities Theory because affective emotional states and persistence on tasks, described by Dewey, act as a precursory set of circumstances that may help facilitate the construction of Hybrid Identities (Gutierrez, 2008). From the existing research on identity formation there is a consensus that individuals tend to incorporate positive experiences and feelings into their identity more readily than negative experiences (Dewey, 1910; Howard, 2000). Therefore, it follows that if students are interested in a topic, there is a greater likelihood they will associate enjoyment with the experience and will be more likely to seek out that experience (Dewey, 1910). Interest Theory (Dewey, 1910) may provide supportive rationale for why students intrinsically persist for longer in the Third Space (Gutierrez, 2008) than when learning takes place in the more traditional, solely academic realm. Additionally, this premise may help to explain why there are so many positive anecdotal comments regarding student engagment during Genius Hour (Krebs & Kirr, 2014). Dewey (1910) drew a positive correlation between student interest in an educational topic and the amount of effort and engagement students would put forth into learning. Student interests usually emerge from authentic, salient experiences, which often occur outside of the classroom (Holt, 1989). When classroom learning activates these prior enjoyable experiences in students, students are more engaged and more willing to persist at difficult tasks (Dewey, 1910). In this last statement Dewey draws a

connection between student interest and self-efficacy which will be discussed in the next section.

The Hybrid Identities Theory (Gutierrez, 2008), suggests students can develop academically when their personal identity that exists outside the classroom is activated by learning opportunities. Given that individuals are most likely to incorporate positive experiences and dialogues into their identities and reject negative experiences (Brophy, 2004), it follows that the majority of the student's established personal identity is composed of genuine passions and interests. Interest Theory (Dewey, 1910) may help explain why students appear to learn more in the 'third space' (Gutierrez, 2008). Interest Theory states that students have heightened arousal, engagement, activity and persistence if they are learning about topics they are already interested in (Dewey, 1910). The learning that takes place from these activities, where there is a strong alignment between the students' personal self and academic self, is often more salient, more easily retrieved and more transferrable to new contexts (Aschbacher, 2009). In summary, the Hybrid Identities Theory (Gutierrez, 2008) describes a mechanism for identity development and Identity Theory (Dewey, 1910) may explain how learning works in this framework.

Approaches to Studying Identity

As noted earlier, identity is influenced by numerous contextual factors which may be environmental, psychological and physiological and that identity, as a construct, is malleable (Faircloth, 2012). While these features of identity make it an aspect of education that can be highly influenced by teachers, they also present some challenges

when it comes to measurement. The following section describes indicators of change and measurement methodologies for classroom teachers and researchers.

Measuring Identity Formation in the Classroom. To measure science identity, we must measure the extent to which students 'become scientists' (Blumenfield, 1991). In Bloom's Modified Taxonomy, science identity formation could be considered the apex of learning as students 'create' a scientific facet of themselves. Following Bloom's Taxonomy, science identity rests on the foundation of knowledge, skills and attributes. While research has shown a strong correlation between identity and competence (Aschbacher, 2009) in science education, there is often a preoccupation with the assessment of low-level knowledge to the exclusion of all else (Marzano, 2004). The Next Generation Science Standards emphasis on the Science and Engineering Practices (National Research Council, 2016), a set of standards that pertain to a student 'doing scientific activities' such as formulating questions, could be an excellent starting point for evaulating identity, especially when one considers identity is defined as the pattern of actions and choices that are demonstrated in a given context (Erikson, 1969). Assessment tools such as performance based-assessments and learning activities, which incorporate project-based learning, may provide excellent opportunities for students to demonstrate science-based patterns of action. What must not be forgotten is the extent to which students see themselves as scientists; students may be competent in science, but fail to integrate science into their global self-concept (Aschbacher, 2009).

It could be ascertained that students work towards self-actualization described by Maslow, when teachers observe them doing science (Anderson, 1988), demonstrating

creativity and problem solving *and* when there is strong integration between their personal world and academic world, evidenced by the formation of a hybrid identity (Gutierrez, 2008). As identity is defined as a collection of actions and choices (Howard, 2000), classroom teachers can best measure changes in identity in the science classroom through demonstrable skills such as the Science and Engineering Practices outlined by the Next Generation Science Standards (National Research Council, 2016). Genius Hour can provide an opportunity for students to demonstrate the Science and Engineering Practices (National Research Council, 2016) as these practices are independent of any specific content area and therefore, students participating in Genius Hour projects are capable of demonstrating these skills regardless of their topic of study.

Measuring Identity In Educational Studies. To accurately measure identity formation, techniques chosen must align with the phenomenon studied. Vygotsky described the formation of identity as an on-going narrative with oneself and with a social community (Howard, 2000). It follows that most studies of identity use mainly qualitative methodologies with a heavy emphasis on student interviews, paired-interviews, qualitative surveys and ethnographic observations (Aschbacher, 2009; Faircloth, 2012; Kaplan & Flum, 2012).

A case-study approach to studying identity is evident in much of the current research (Aschbacher, 2009; Faircloth, 2012; Lee, 2007), with trustiworthiness established through emergent thematic analysis in numerous data sources such as interviews, observations, evaluation of learning artifacts and rich contextual descriptions of both the participants and the learning activities. Therefore, an exploratory case study

approach was selected for this study because it aligns with the practitioner description of Genius Hour, where all students participate in Genius Hour at the same time and there is dialogue between students (Juliani, 2014). It is important to note that while Genius Hour tasks are highly individualized, the experience of Genius Hour is a group of students acting in a learning community (Juliani, 2014), making a case-study a logical approach. Additionally, students from one location may have similar 'funds of knowledge' as described by Lee (2007), consequently enhancing understanding of each other's work. For example, many of the students in this study regularly participate in outdoor recreation. Consequently, many of the students in this case study value nature and possess a working knowledge of outdoor activities. The students' similar 'funds of knowledge' may equate to students finding greater value in each others' projects due to greater understanding and increased personal relevancy.

Science Identity

The construction of science identity may be of critical importance when one considers the increasing demand for students in STEM fields (National Research Council, 2016). Current research explores reasons as to why many students shy away from careers in the sciences citing reasons such as a lack of understanding of what types of science careers exist and what scientists do, difficulty seeing themselves as scientists and a lack of self-confidence to perform scientific tasks (Aschbacher, 2009). To address these issues, researchers have discovered several promising strategies such as increasing mentoring opportunities between real scientists and students, providing students with autonomy to carry out their own scientific explorations and the application and practice

of science in authentic contexts (Kantier, 2009). Some identity research states that 'we become what we do' (Anderson, 1988); therefore, it follows that the more opportunities students are given to practice science in the role of a scientist, instead of acting as a passive recipient of information, the greater the likelihood of these students developing a science identity and choosing science-based careers.

Genius Hour, when implemented in science classrooms, may provide the autonomy and the time for students to try on the role of 'scientist'. At its core, Genius Hour is an instructional strategy that promotes inquiry learning because students are asking their own questions and carrying out research and investigations independently (Juliani, 2014). Research on inquiry learning emphasizes students 'doing science' as a primary mechanism to develop knowledge and understanding (Llewellyn, 2007). Additionally, 20% Time during Genius Hour may provide students with more substantial opportunity to develop mastery skills performing science, leading to increased self-confidence. The opportunity for students to work with experts in their community and to share their projects globally during Genius Hour may also increase the likelihood of students acquiring STEM mentors. The facilitation of the 'third space' (Guiterrez, 2008) may also assist students in gaining knowledge of potential STEM careers. For example, a musical student may realize during Genius Hour that the construction of instruments is a STEM field they could be passionate about which they may not have previously considered. And finally, Genius Hour may act as a 'third space' (Guiterrez, 2008) where students apply science to authentic and personally meaningful contexts, thereby

increasing their perceived value of science as a discipline and the value of science in their individual lives, regardless of whether they pursue careers outside of STEM.

Self-Efficacy

In addition to identity, self-efficacy also plays a critical role in students' success in STEM (Anderson, 1988). Therefore, self-efficacy was examined as part of this study because research suggests many students lack self-efficacy, particularly in the sciences (Anderson, 1988). Self-efficacy research aligns with Genius Hour, particularly its fundamental value of 'mastery' as the greater the length of time a student is immersed in a task, the greater the likelihood of achieving competence in that area (Brophy, 2004). Self-efficacy is defined as an individual's perception about their ability to succeed and accomplish a task (Kaplan & Flum, 2012). An individual's self-efficacy is influenced by past performance, verbal persuasion, presented asinternal or external dialogue,, physiological cues and vicarious experiences where the individual observes others performing (Howard, 2000). When examining the factors that influence self-efficacy (Howard, 2000), it becomes apparent that self-efficacy is constructivist (Erikson, 1969) as the belief in one's self is based largely on past experiences. This constructivist description of the importance of past experience is found in the Genius Hour instructional technique where students are prompted to reflect on their existing interests and passions when choosing a topic of study.

Approaches to Studying Self-Efficacy

Self-efficacy, a belief in one's ability to perform certain tasks or address certain challenges, often presents challenges to study because it is a perception of ability, rather than an absolute measure (Anderson, 1988). Each student has their own definition of success and this variable yardstick can present problems for researchers (Erikson, 1969). For example, a high achieving student may rate their self-efficacy as average, despite having demonstrated exceptional sklls on a task, likewise, a student that has poor or incomplete conceptions of a standard of excellence may over-estimate their self-efficacy and have a sense of false confidence (Aschbacher, 2009). However, there is a correlation between the feedback students receive from others and their belief in their own abilities (Dewey, 1910). To address these problematic areas, researchers can measure students against themselves at a previous point in time, rather than performing peer to peer or peer to group comparisons (Dewey, 1910).

Longitudinal studies often provide significant insight into changes in self-efficacy because of the large number of snapshots taken over a longer duration (Guba, 1994). Another strategy can be a comparison where students are asked to separate how others see them and how they see themselves (Guba, 1994). This strategy serves to differentiate between the confidence students have in themselves and the perceived confidence and aptitude assigned to them by their peers and teachers. Through the comparison of the self-constructed appraisal of a student's self-efficacy and that formulated by others, a researcher can determine if there is congruence (Erikson, 1969). This congruence is

significant because the greater the congruence between self constructions and those assigned to us by others, the more stable these beliefs may be (Erikson, 1969).

In relation to Genius Hour, when students share their projects with others, this act may reaffirm their beliefs about their abilities or challenge them if there is a difference between their self-efficacy and how others perceive their competence. And because there is an established relationship between self-efficacy and identity, the formation of greater self-efficacy in students may contribute to identity formation (Aschbacher, 2009). The longitudinal study of Genius Hour in this research may provide insights into how this instructional technique influences self-efficacy over time and which components of the technique are the most salient in developing self-efficacy.

Self-Efficacy, Identity & Interest Theory

There is a mutually influential relationship between enjoyment and self-efficacy, where students are more likely to have a greater ability to believe in their aptitude when they are experiencing positive emotions while completing a task (Dewey, 1910). When students participate in a task that aligns with their existing personal identity and schemas, high levels of engagement and motivation are demonstrated (Brophy, 2004), therefore it follows that greater time on task and more thorough interaction with content would promote mastery and competence. The relationship between Interest Theory and self-efficacy as described by Dewey (1910) delineates a pattern where students have greater interaction with content they are interested in, both time investment and level of attentiveness, greater persistence on difficult tasks and greater resilience when setbacks are encountered. He postulated there is a strong intrinsic motivation to learn when the

subject matter is something the students are authentically interested in (Dewey, 1910). As Genius Hour is learner-centered and overtly provides students with the opportunity to explore individual passions, Interest Theory (Dewey, 1910) may help to explain anecdotal teacher observations that note increased engagement and time on task (Krebs & Kirr, 2014).

Why is Developing Science Identity and Science Self-Efficacy Important?

The development of science identity and science self-efficacy is not only important to STEM students, but all students as science competencies, described by the NGSS Science and Engineering Practices, are interdisciplinary skills (National Research Council, 2016). For example, a pastry chef must have a sound understanding of chemistry and have the skills to carry out investigations when creating new recipes. While he/she may not identify their career as a STEM career, their pastry chef tasks utlize science as both a body of knowledge and more importantly, as a way of thinking. Genius Hour may develop 'science as a way of thinking' by providing opportunities for the integration of personal interests and academic science knowledge and skills (Juliani, 2014).

To obtain sufficient 'buy-in' from teachers, to the degree where they are willing to change 20% of their classroom practices to facilitate Genius Hour, tangible gains for students, like positive influencees on engagement and learning, must be made clear. Consequently, the development of identity is significantly linked to engagement in learning (Faircloth, 2012). Dewey's Interest Theory (1910) is based on the premise that

genuine interest in a concept occurs when a learner identifies ‘self’ with the content, promoting intrinsically motivated and self-initiated exploration. If students are naturally curious about a concept, they will engage with it for a longer period of time in addition to placing value on the knowledge and the process of learning (Holt, 1989). Both of these findings are significant when one considers the aspiration of teachers to foster lifelong learning in students. Sustained attention and interaction with content could be particularly beneficial to students with learning challenges or knowledge gaps in the sciences as there is a greater opportunity to expose misconceptions or incomplete conceptions. Misconceptions and incomplete conceptions are more likely to be exposed if a learner participates in experiences that make them confront their misunderstandings (Llewellyn, 2007).

Additionally, a link between identity, engagement and goal orientation of students has been established, suggesting classrooms are a place where students practice learning concepts simultaneously with self-discovery (Faircloth, 2012). Meaningful learning environments are critical for motivation, resiliency and self-efficacy. There is often a disconnection between established curriculum and what knowledge is deemed valuable by students (Holt, 1989). Current studies have suggested that underperformance by students in school may be more attributed to the value gap between what knowledge is considered important by teachers and individual students, than deficiencies in intellect (Klos, 2006). The Hybrid Identities model (Gutierrez, 2008) may close this gap by engaging students in exploration of their interests and connecting applicable curriculum.

Additionally, teachers may be better informed regarding their students' values from mindfully creating the Third Space (Gutierrez, 2008).

Identity formation is an important facet of inquiry learning (Aschbacher, 2009). Current research suggests that students who draw connections between school content and who they are or who they aspire to be, possess a more exploratory approach to learning (Kaplan & Flum, 2012). This exploratory approach to learning may cultivate innovation and creativity skills in students (Anderson, 1988). Inquiry learning is demonstrable in students taking academic risks, developing questions and extending themselves beyond their current area of functioning; such ways of thinking are more likely to be transferrable to a wide range of contextual challenges (Aschbacher, 2009). In summary, by focusing on soft-skills such as identity formation and self-efficacy, through the use of techniques such as Genius Hour, teachers may foster gains in student engagment, sustained attention, resiliency, inquiry thinking, innovation and the transferrability of skills and knowledge to new contexts.

The Role of Identity Formation and Self-Efficacy in Science Education

Identity formation and self-efficacy may have even greater importance in the sciences than other disciplines because of the disproportionately low numbers of North American students seeking careers in science fields (Anderson, 1988). Creating a school science culture with classrooms filled with students who see themselves as scientists could be an important first step in cultivating interest in STEM fields, fields which are critical to economic growth and sustainability in North America's knowledge economy.

Learning is defined as the development of skills and knowledge through experience. John Holt (1989) emphasized the importance of experience on learning and postulated children are learning all the time and the role of teachers is to facilitate learning experiences that are authentic. Critics of current school models that emphasize rote memorization to sustain the accountability culture in education, suggest that the lack of authentic learning experiences has robbed children of their natural curiosity to learn (Robinson, 2007). The field of science is rooted in curiosity. Is it any real surprise that there is a massive shortage of workers entering STEM fields (Aschbacher, 2009)? Students' growing distrust of science, their view that science is an activity only practiced in a lab by 'real scientists' has equated into less students choosing scientific career paths.

The formation of the Next Generation Science Standards (National Research Council, 2016) may reposition students' current view of science as a noun, where it is a body of knowledge to be memorized, to science as a verb, where it is instead, actions that can be practiced. This shift may improve science self-efficacy; if science is a skill that is practiced many times in the classroom, it follows that science may be a career that students perceive is within their reach. Science self-efficacy, a belief in one's ability to perform scientific tasks is a wide variety of contexts, is fostered through the Next Generation Science Standards (National Research Council, 2016) focus on skill development, conceptual understandings and transferrability versus memorization of discrete facts. Continued application of skills and content knowledge in unique and dyanmic contexts, such as those created by Genius Hour, may foster increased self-efficacy in the sciences (Anderson, 1988). The inherent focus on inquiry, which

emphasizes the procedures used to make sense of a scientific task, utilizes students existing experiences and strengths, rather than traditional methods which often reveal student weaknesses; such a change may put science competence within the reach of a greater population of students (Kessels & Taconis, 2012).

If a goal is to increase the number of students in the STEM fields and the quality of their preparation, it is logical that science education should focus on the development of science identity, defined as the extent to which students see themselves as scientists, in students (Anderson, 1988). Students with strong science identities possess self-efficacy and demonstrate scientific skills and competencies (Aschbacher, 2009). The development of a science identity encapsulates all other forms of science learning and can be prioritized as the critical over-arching science education goal and therefore, is worthy of research exploration.

Genius Hour

Although little to no empirical evidence or formalized theoretical thinkings exists on Genius Hour, it is an instructional approach with widespread implemenation across the country being heralded as a mechanism for encouraging the development of identity and self efficacy. Genius Hour is an instructional strategy that requires students to pursue their passions and build connections between their personal interests and school curriculum (Wettrick, 2014). Genius Hour can be thought of as a designated learning time and space where 20% of a student's instructional time is learner-centered (Juliani, 2014). The three foundations of Genius Hour are autonomy, mastery and purpose

(Kesler, 2014). *Autonomy* describes students having control over their content and their execution of a project and in some cases, students may choose indicators of quality for assessment purposes (Kesler, 2014). *Mastery* describes the commitment to growth-mindset learning, where set-backs are seen as learning opportunities and the focus of the project is on the learning journey rather than the final product (Kesler, 2014). *Purpose* encapsulates student self-reflection on their personal passions and their value in the real world (Kesler, 2014).

The aims of Genius Hour include greater student engagement, self-efficacy, self-awareness and a renewed curiosity in learning (Krebs, 2013). Genius Hour can be thought of as a prolonged application of academic learning to real world contexts; an amalgamation of school smarts and street smarts, where the value of academic knowledge is discovered authentically as students solve problems that are personally meaningful (Krebs, 2013). Practitioner and student accounts of Genius Hour are centered on themes such as increased interest and engagement in school, fostering of creativity and innovation, increased confidence and persistence in difficult tasks and feelings of pride and ownership over one's own learning (Krebs & Kir, 2014). An extensive formalized review of multiple information sources including blogs, wikis, webpages, books, videos, articles and infographics will be presented in Chapter Four as operationalizing Genius Hour through practitioner consensus building was an aim of this study.

Description of the Genius Hour Instructional Technique

The invention of Genius Hour is often attributed to Google's business model, where employees are given 20% of their work week to devote their time to projects they are passionate about. However, many point to Daniel Pink's (2011) book, *Drive: The Surprising Truth About What Motivates Us* for the conceptual underpinnings of why Genius Hour has positive results. In that book, Pink (2011) described three pillars of motivation: autonomy, mastery and purpose. While his book largely described motivation in an adult context and he challenged educators to apply the principles of Google's 20% time to the classroom to increase interest and innovation among students (Pink, 2011). A thorough exploration of the available resources on Genius Hour indicated there is relative fidelity to Pink's (2011) three pillars. Alignment to these pillars will be highlighted in Chapter Five.

The bulk of available information regarding Genius Hour is centered on practical implementation of the instructional technique, however, just as Genius Hour provides a lot of latitude for students, there is a lot of teacher authorship in the implementation of the technique (Juliani, 2014). In Chapter Four, the researcher will discuss which features of Genius Hour there is a strong consensus among practioners on, and which features appear to be individual stylistic choices by classroom teachers. For this section, more weight will be given to the existing book publications and associated multi-media on this topic.

Genius Hour can be thought of as a practitioner developed instructional strategy that facilitates the blending of personal passions with academic knowledge and skills

from a wide variety of disciplines (Kesler, 2014). The principle components of Genius Hour are radical student autonomy where students reflect on their personal interests and the establishment of a structured time and space for students to pursue their passions in the school environment (Juliani, 2014). A more theoretical discussion of Genius Hour and its position in existing literature will take place in the subsequent section, while the focus of this section in on the practical implementation of Genius Hour in the classroom. During Genius Hour, students are in control of their own learning and choose topics about which they are passionate, while the role of the teacher is to act as a facilitator of learning (Juliani, 2014). Facilitation may take the form of cultivating reflection on student interests, assisting students in clarifying their research topics, asking leading questions to connect curriculum and their research projects, using the socratic method to highlight deficiencies in student plans and projects and brainstorming remediations with the students, connecting community resources with students, creating a time and space for student projects, assisting in the development of softskills such as time management and ongoing formative assessment and assisting in the communication of learning (Krebs & Kirr, 2014).

Strategies for Genius Hour Implementation

There are many rich suggestions for implementation of Genius Hour in the classroom found in the reflections of practicing teachers (Krebs & Kirr, 2014). Some teachers report students have a difficult time choosing a topic (Juliani, 2014). Book resources suggest that the choosing of a topic should not be rushed and can be coaxed out

of students by asking more practical questions such as “what would you rather be doing if you didn’t have to be in school right now?”, rather than imposing the rather abstract , ambiguous and often daunting task of askng a student to articulate their passion (Juliani, 2014). Additionally, topics can be suggested by noticing individual nuances about the student, for example, a student that has numerous articles of clothing with cats on them may have an interest in researching new cat breeds such as hairless cats (Juliani, 2014). Observant teachers may be able to direct students to pay greater attention to their likes and dislikes and help them in the discovery of topics they are passionate about, which is critical to student engagement throughout the project (Juliani, 2014).

The Importance of Monitoring Learning During Genius Hour

Teacher blogs report that monitoring learning on long-term projects like Genius Hour is important to keep students progressing towards learning goals (Krebs & Kirr, 2014). Practitioner suggestions to monitor learning include student conferences, goal setting, formative assessment checks, learning logs and journals, interim assessments or digital monitoring through platforms like Google Docs (Krebs & Kirr, 2014). When students are new to project-based learning the soft skills of project management, time management and organization must be overtly taught and supported by the teacher to promote student success (Juliani, 2014). Additionally, the autonomous learning path of Genius Hour sometimes leads to student frustration when they are challenged by their project in terms of content understanding or execution (Juliani, 2014). Practitioners suggest that creating a growth mindset culture (Dweck, 2006) can help increase student

resiliency and reframe ‘failures’ as opportunities for problem solving (Juliani, 2014). Teachers should emphasize the learning process rather than the final product. This approach aligns especially well with inquiry learning in the sciences, where the real nature of science is often messy (Anderson, 1988) and findings lead to more questions than answers at certain stages of the learning process. One of the major hesitations of teachers to implement Genius Hour is centered on the topic of assessment (Krebs & Kirr, 2014). Practitioners often question how to assess the variety of projects presented by individual students and maintain fairness (Juliani, 2014). Book resources suggest that standards based assessment can help teachers ignore the form students used to communicate their understanding and skills and focus on the degree of understanding of a knowledge standard or degree of performance for a skill standard (Juliani, 2014). In terms of science education, the Science and Engineering Practices and Cross Cutting Concepts focus on knowledge and skills that possess transferrability (National Research Council, 2016) to a wide variety of contexts and therefore the demonstration of knowledge and skills may take on a greater variety of formats. A survey of the existing publications and practitioner accounts of Genius Hour will be more thoroughly discussed in Chapter 4. This is a necessary endeavour to clarify the nebulous concept of Genius Hour for which there is a relative absence of peer-reviewed research publications.

Genius Hour and the Third Space

Guiterrez (2008) describes a conceptual mechanism by which identity formation can occur in school settings. While such theoretical constructs further our understandings in education, they are often difficult to apply in classrooms as teachers sometimes

struggle to implement theory in practical ways. Likewise, solely practitioner oriented instructional strategies are sometimes perceived as lacking credibility; therefore it is essential to root the practical implementation strategy of Genius Hour in conceptual theories to fully understand the mechanisms at play. In many ways, there is a considerable alignment between the design and goals of Genius Hour with Hybrid Identities Theory (Gutierrez, 2008). The radical autonomy component of Genius Hour where students select topics of study based on personal interests promotes identity hybridization (Lee, 2007) between the academic world and students' personal worlds. By bridging the gap between the personal realm and academic realm students can find purpose, a component of Genius Hour (Kesler, 2014), and value in their work. To create the third space and to effectively implement project-based learning, the teacher must value the 'funds-of-knowledge' (Lee, 2007) which already exist in each student and guide their extension and application to new contexts by acting as a facilitator. 'Funds of knowledge' can be any skills or knowledge that exist in the academic realm or the informal realm, sometimes referred to as 'street smarts'(Lee, 2007). It is important for the teacher to value 'funds of knowledge' in the informal realm as these are often the types of knowledge deemed valuable and meaningful by the student and may consequently be a starting point to engage students in more academic forms of learning (Lee, 2007). Teachers can assist students that may lack the self-awareness to self identify their passions by asking questions such as 'what would you rather be doing right now if you weren't in school?' (Juliani, 2014). Such questions respect the autonomy of learning, but also elicit the metacognitive skill of self-reflection (Juliani, 2014).

The 20% classroom time devoted to Genius Hour tasks can be thought of as the third-space described by Lee (2007) – a time where students can blur the lines between home values and school values. To facilitate the construction of the third space, teachers begin conversations with students about their interests to blur the lines of typically compartmentalized identities (Gutierrez, 2008). Because most Genius Hour projects are very easy to share (Juliani, 2014), blurring the lines between home and school can occur in students' families and larger communities. Genius Hour may act as conversational piece for students as they discuss their progress, their challenges, seek advice and share success (Wettrick, 2014).

Internal and external dialogues where students are connecting their passion to their project, can create a hybridized identity (Aschbacher, 2009). The likelihood of integration of school identity and personal identity is increased if students feel their project was an enjoyable experience, as people rarely integrate unsavoury experiences into their self concept, if they felt it was of high quality based on their values, as they are the ones defining the task (Brophy, 2004) and if their work is positively received and deemed valuable by others (Aschbacher, 2009).

The mastery component of Genius Hour supports the third space (Gutierrez, 2008) where the value of continuous practice and continuous dialogues between personal and academic values is seen as a method to foster lasting changes in identity. Throughout Genius Hour there are ongoing conversations between student and teacher, student to student and student to community (Kesler, 2014). Such conversations may create a well worn path between academic and personal values and serve to answer the ever present

question, ‘why are we learning this?’ In the third space, the teacher may assist the student in applying content knowledge to their passion, in essence developing a greater understanding of both their passion and the content. The third space provides the time and place for students to determine and solidify their passions, interests and values and gain a greater understanding and appreciation for their interests (Gutierrez, 2008). In summary, Genius Hour’s 20% time can be thought of as practitioner’s description of the Third Space where its fundamental components of autonomy, opportunity for master and social dialogues (Kesler, 2014) facilitate the identity hybridization described by Guiterrez (2008).

Research Philosophy

The phenomenon in this study will be viewed through a post-modernist constructivist lens which aligns with the current research on identity formation (Aschbacher, 2009). Constructivism occurs when students make meaning from forming connections between their personal experiences and ideas. A student’s reality is based on the successful integration of knowledge and ideas into an existing structure that is created from the student’s lived experiences (Erikson, 1969).

The development of identity and self-efficacy, attributes that are influenced by external interactions, are largely self-constructed (Aschbacher, 2009) and incorporate the sum of students’ prior experiences which is well situated in constructivism. A fundamental component of the Genius Hour instructional technique has a strong focus on students’ individual interests and passions; uniqueness, creativity and self-exploration are

encouraged throughout the Genius Hour process (Wettrick, 2014). While a student's initial 'funds of knowledge' are accessed at the beginning of Genius Hour, their knowledge may be more wholly developed and organized throughout the process.

Additionally, radical autonomy, where students design their project as well as determine indicators of quality, suggests that Genius Hour is aligned with values of individualism. Genius Hour promotes the skills of self-reflection and metacognition as students assess their personal values and skills in choosing a topic and mode of communication for their ideas. When taken together, the constructivist nature of identity building and the strong emphasis of the Genius Hour technique on individualism, the philosophical approach most fitting is post-modernism. Post-modernism, when applied to education, elevates the role of the student from a passive recipient of knowledge to an active constructivist of learning (Guba, 1994). If knowledge were considered a book, post-modernism's focus is on the meaning-making of the reader, instead of the intended message of the author. Post-modernism acknowledges that students approach learning with different values, experiences and expectations. The meaning students assign to learning may be at least as equally important to the content learning itself. The Genius Hour instructional technique provides students with unstructured time to self-reflect on their passions, interests and experiences and encourages students to develop an 'authorial voice' in their learning. The role of the Genius Hour teacher is to encourage the expression of individual authorial voices. In contrast, traditional teaching approaches that utilize direct instruction and operate from a largely positivist position (Schunk, 2012), with the goal of harmonizing student voices into one cohesive, logic based,

singular reality. Additionally, allowing the novice (the student), determine the direction of their learning rather than the expert (teacher) during Genius Hour aligns with post-modernism. A post-modernist classroom would look more like a mosaic of learning than a single, artfully crafted piece. Further, there is a strong congruence between the underlying values of Genius Hour and the post-modernist paradigm, making it the lens that would likely represent this phenomenon with the highest degree of fidelity.

Finally, and most importantly, a post-modernist approach can be useful in investigating phenomenon for which there is no established consensus, as is the case with Genius Hour. This is because Genius Hour allows participant voices to establish what their individual reality is and the researcher to discover common themes to operationalize a new learning technique (Patton, 2001). Embracing the concept of multiple perspectives, a post-modernist approach can often yield information that more wholly captures a particular phenomenon (Schunk, 2012).

Most importantly, the post-modernist lens aligns with identity and self-efficacy as it acknowledges multiple realities. Identity is a personal construction (Kaplan & Flum, 2012) and a post-modernist approach allows for the exploration of the many facets of identity as well as the complex set of factors influencing it. Perhaps the greatest strength is using a post-modernist paradigm to investigate identity is its acknowledgement of the importance of individual values. If identity consummates who we are, how we act and how we think about ourselves (Aschbacher, 2009), the value we assign to certain experiences and interactions, influences the saliency of such events (Howard, 2000) and if they are subsequently discarded or integrated into our self-conceptions. Post-

modernism is not concerned with a rational construction of reality (Schunk, 2012), but rather the stories we tell ourselves. This paradigm allows for greater breadth of expression from research participants (Schunk, 2012) and is capable of capturing the diversity that exists between individuals' identities.

Summary of Chapter Two

Although the current literature and publications on Genius Hour are from a practitioner's perspective, when this method is explored through historical and contemporary models (Guiterrez, 2008; Anderson, 1988; Vygotsky, 1962) there is a strong conceptual alignment. The overlap between Genius Hour and research on identity formation exists in the areas of motivation, constructivism, the value of narratives with oneself and the larger learning community, the importance of student interest, the bridging of academic and personal worlds, the inquiry approach, the importance of context and the role of mastery learning. The exploration of the Hybrid Identities Theory (Gutierrez, 2008) and Interest Theory (Dewey, 1910) was an attempt to situate Genius Hour, an educational technique which is currently unvetted in peer-reviewed research, in existing conceptual models.

METHODOLOGY

Introduction

The objective of this study was to determine the long-term influence of Genius Hour on high school science students' identity and self-efficacy, with special attention given to how these traits were developed in the discipline-specific domain of science education. A longitudinal, exploratory case study method was used to investigate the development of identity and self-efficacy for freshman physical science students participating in Genius Hour at a medium sized high school in the Northern Rockies. An exploratory case study approach was chosen due to the lack of formal, peer-reviewed research on the Genius Hour instructional technique. This method was also employed to operationalize the Genius Hour technique and identify the salient features of Genius Hour and how they develop identity and self-efficacy. Exploratory case studies are used when there is a lack of a substantial research base, as in the case with Genius Hour, to examine a phenomenon from many angles and can be thought of as a form of consensus building (Guba, 1994). Exploratory case studies are used in pioneering research where the researcher does not have previous studies suggesting where to look, what to look for or how to examine a phenomenon (Guba, 1994). Numerous rich data sources were collected such as student interviews for a longitudinal period of two years to fully explore the lasting influence of Genius Hour on student identity and self-efficacy.

Significance of the Study

There are currently few, if any, peer reviewed studies of Genius Hour, with the majority of the information available being anecdotal or theoretical. The aim of the research is to add specificity to the technique of Genius Hour through an empirical investigation, as well as establish a data-supported rationale for its use in the classroom. The importance of developing science identity and self-efficacy in learners is great, as there is an ever-increasing demand for STEM professionals (Fraunenheim, 2006; Tseng, Chang, Lou & Chen, 2011). Genius Hour is a technique to cultivate science literacy, appreciation and engagement in all learners, which strongly aligns with the Next Generation Science Standards (National Research Council, 2016). Further, the development of identity and self-efficacy are important educational goals and they assist students' self-actualization process (Brophy, 2004). When such factors are a conscious part of teaching, education can be elevated from a vocational prepatory school to an environment that cultivates life-long learners.

Research Methodology Overview

In this mixed methods study, the influence of the Genius Hour instructional technique on identity and self-efficacy was examined using a longitudinal, exploratory case study method. Much of the current body of knowledge regarding Genius Hour has not been peer reviewed and is largely anecdotal in nature. This body of knowledge comes from educators that have implemented the technique in their classrooms and have found success in those implementations. But again, little peer reviewed research exists

on Genius Hour; especially in consideration of measurements regarding its influence on identity and self-efficacy. With the absence of valid and reliable research protocols regarding Genius Hour, an exploratory case study sought to gather large quantities of data to operationalize the Genius Hour technique and examine the technique from many angles. Research pertaining to the operationalization of the technique, identity and self-efficacy were used in this exploratory case study, while other data will be explored in subsequent publications. Exploratory case studies are often used as the first steps in pioneering research and serve to form early conceptions of a phenomenon that are later expanded upon and refined in further studies (Patton, 2001) and for this reason it aligns with current state of Genius Hour.

Data collection for the case study methodology included both qualitative and quantitative measures. The influence of Genius Hour on identity and self-efficacy of high school science students used qualitative research in a variety of interviews and questionnaires with open response questions. Qualitative research approaches promote the uncovering of nuances, individual experiences and emotions associated with learning experiences (Schunk, 2012). A hallmark of Genius Hour is the focus on the individual student's personal passions (Juliani, 2014), giving them the ability to choose a research topic and execute a self-designed plan, described as 'radical autonomy'. The diversity of educational experiences within a class may not be well captured by uniform quantitative instruments, therefore a qualitative methodology might allow for greater participant expression. While a potential drawback of predominantly qualitative methodologies is lesser generalizability, qualitative data may better capture the richness and nuances of

individual experiences. Identity is a complex, multi-dimensional construction, it is important for the researcher to offer opportunities to participants for a broad range of expression (Schunk, 2012).

Qualitative data sources for this study included: individual interviews, small group interviews, whole class interviews and open responses on exit cards during the Genius Hour process. While a potential drawback of quantitative methodologies is that individuals are reduced to numbers (Schunk, 2012), statistical analysis can increase the strength of claims and generalizability by revealing numeric correlations between the variables. Quantitative measurements can reveal the extent of an influence through ranking which can provide greater insight into the salience of the learning experience than qualitative adjectives where word choice can be influenced by numerous factors such as vocabulary abilities, articulateness, mood (Schunk, 2012) and there is subjectivity in interpreting words such as 'meaningful' and 'fun'. Qualitative data was transcribed and sorted by theme to generate summaries of student experiences with Genius Hour. Additionally, qualitative data collected from each individual was analyzed to determine individual metamorphosis over the two year study period.

Quantitative measures of Genius Hour in this mixed methods study were used to describe large trends in the full sample of students, as well as assist in the triangulation of the qualitative data. The quantitative data sources for this study included: Likert rating scale questions as well as a numeric self-assessment on the eight Science and Engineering Practices (National Research Council, 2016). Quantitative approaches such as student scoring of perceived abilities, a measure of self-efficacy, or identity helped the

researcher respond to the first research question that asked ‘how much did Genius Hour influence identity and self-efficacy?’ Students were required to reflect quantitatively their perceived abilities on the Science and Engineering Practices (National Research Council, 2016) at the different time intervals in the study period as well as qualitatively reflect on their growth over the course of Genius Hour and beyond in interview questions that pertained to their appraisal of skill and knowledge development.

Quantitative analyses were conducted to provide insight into the degree of influence of this instructional technique in a population and may subsequently influence claims about its instructional value. This information would be useful as Genius Hour is time intensive and more pre-service and practicing teachers may adopt this technique if it was determined to have profound effects on students. Robert Marzano quantified the effect of various instructional techniques such as ‘using advance organizers’ on memory and his work has great acceptance among practitioner minded teachers (Marzano, 2004). As one of the principle components of Genius Hour is the focus on the individual (Kesler, 2014) it would have been counterintuitive to utilize solely quantitative techniques which wash away outliers and confine responses to pre-established criteria. For example, in a Likert survey the researcher could identify the components of Genius Hour that she thinks would be salient to students, such as autonomy and student centeredness, only to miss unanticipated rich descriptions such as “I really liked Genius Hour because I improved my basketball skills and developed something in common with my brother”. This example underscores the value of a mixed methods approach in providing the researcher a more complete view of the phenomenon.

Research Matrix

The following research matrix summarizes the data instruments used to address each research question.

Table 1. Genius Hour triangulation matrix.

Research Question	Instruments	Rationale
Q.1 How does Genius Hour influence student identity and self-efficacy in high school science students?	Exit Card Data (3 collections during Genius Hour) Class Discussion (immediately following) Individual Interviews (immediately following, 6 months post) Small Group Interviews (18 months post, 24 months post) Examination of subsequent activities following Genius Hour	This broader topic encompasses all facets of identity and self-efficacy which are not necessarily discipline specific (ex. Project management skills, interest in making digital productions)
Q.2 How does Genius Hour develop science identity?	Identity Rating Scales (pre/post) Exit Card Data (3 collections during Genius Hour) Class Discussion (immediately following) Individual Interviews (immediately following, 6 months post) Small Group Interviews (18 months post, 24 months post) Examination of subsequent activities following Genius Hour	The longitudinal component of the study is important to determine if Genius Hour had anly lasting influence on science identity.
Q.3 How does Genius Hour develop student science self-efficacy?	Self-Efficacy Rating Scales (pre/post) Science and Engineering Practices Rating (pre/post) Exit Card Data (3 collections during Genius Hour) Class Discussion (immediately following) Individual Interviews (immediately following, 6 months post) Small Group Interviews (18 months post, 24 months post) Examination of subsequent activities following Genius Hour	Qualitative questions were used to uncover the skills and attitudes developed by Genius Hour that influenced science efficacy. When studying an educational intervention, a determination of 'lasting effect' is very important. If students demonstrated a change in subsequent behavior after Genius Hour, claims can be made that learning has occurred. Transferrability of skills can also be assessed if Genius Hour skills are used in new contexts by students.

Study Design

As indicated, the purpose of this study was to investigate identity and self-efficacy formation through the Genius Hour process, with special attention given to the development of science identity and science self-efficacy. The major research question guiding this study was: How does participation in Genius Hour influence identity and self-efficacy in high school science students? Identity and self-efficacy were studied broadly because the existing publications on Genius Hour describe the practice as a cross-curricular teaching strategy (Juliani, 2014). The following sub-questions, pertaining specifically to the discipline of science, were also used to structure the investigation: How does Genius Hour develop science identity? How does Genius Hour develop science self-efficacy? Science identity and science self-efficacy were studied specifically because Genius Hour may be a technique to promote the Science and Engineering Practices (National Research Council, 2016). Again, while there are practitioner accounts of the effective use of Genius Hour in science classrooms by practicing teachers (Krebs & Kirr, 2014), there is a lack of peer-reviewed research in this area. Additionally, there is a recent research emphasis on the development of science identity as a mechanism to improve the number of students pursuing STEM (Anderson, 1988). Because Genius Hour is a highly personalized instructional strategy that promotes student autonomy, it may be an appropriate instructional technique to develop science identity.

A longitudinal exploratory case study was used in this study to develop a better understanding of the influence of Genius Hour over time. An exploratory case study was

used because of the limited research basis regarding Genius Hour. Exploratory case study methodologies are often used in emergent fields to establish preliminary findings before cross-comparisons are made to better address generalizability (Schunk, 2012). In essence, exploratory case studies often answer 'what is happening with this phenomenon?' while research that examines phenomena in more than one context answers the question 'is this phenomenon experienced similarly across diverse contexts?' (Schunk, 2012). Because both identity research and Genius Hour research can be considered emerging fields of study, an exploratory case-study was the most logical approach. The longitudinal aspect of the study was implemented because constructs such as identity are often malleable over time (Erikson, 1969). Additionally, a longitudinal study can create stronger and more valid claims than studies that capture the effect of an educational intervention at one snapshot in time (Schunk, 2012).

Research Context

The research site was a large high school with a total student population of 1,974 students. The high school was in a fairly affluent region, with per capita income of $26 427, predominantly Caucasian (95%), town in the Rocky Mountains, USA (US Census Bureau, 2000). The participating teacher was selected based on his characteristics of strong student relationships, flexibility, 28 years teaching experience and strong innovation in the science classroom. He has taught middle school, high school and post-secondary graduate courses with numerous local and statewide teaching awards. All 136 of the freshman physical science students participated in Genius Hour study, and a representative sub-sample of these students was selected by the participating teacher,

(n=3-8) to participate in the longitudinal study. It is important to note that the sub-sample began as eight students and due to attrition factors such as student transfers, the number of students remaining in the sub-sample at the end of two years was three students.

The Genius Hour instruction occurred one to two days a week over a six week period for a 50 minute period, or approximately 20% of classroom instructional time. Data collection occurred throughout the entire implementation process, including prior to the instructional phase, during the instructional phase and immediately at the culmination of the instructional phase. Further, longitudinal data was collected, six months, 18 months and 24 months following the instructional phase. The sub-sample consisted of an equal number of males and females, varying in science ability. These students were in the general stream science population and did not have specialized learning plans.

Operationalizing Genius Hour

First, to understand the influence of Genius Hour on students' identity and self-efficacy, the researcher had to operationalize Genius Hour. Due to the lack of peer-reviewed studies on Genius Hour, an analysis of the available information from practicing teachers present in online blogs, wikis, informational videos, videos of student projects and practitioner minded books was examined to better understand and define the Genius Hour technique for the purposes of this study. Thematic analysis was performed and the major project criteria and the role of the student and the teacher were determined and defined. Each informational source was recorded in a table with the headings 'role of teacher/ role of student', 'traits developed by Genius Hour/ Goals', 'instructional

method', 'values' and 'other' (Appendix C). After the available sources were recorded into the table, each column was analyzed for similarities and differences. The similarities were noted as characteristics and or descriptions in which there appears to be some consensus among educators. All the commonalities between informational sources were combined to create a description of the educational technique and it was this technique that was used in the study.

Studying Genius Hour:
Treatment Description

Once Genius Hour had been effectively operationalized by the researcher, the investigation started to focus on the implementation of a Genius Hour intervention. In this study of Genius Hour, students chose a topic for which they were passionate and examined it through a scientific lens. For example, a student may choose to study 'the science of skateboarding' with their research delving into the physics of the various styles of skateboards by examining wheel positions and board length. Skateboarding, in this instance, was part of the student's established identity. A description of the assignment is found in Appendix A. All students were encouraged to choose a topic of study that was personally meaningful. A list of all student topics was created to showcase the diversity of student projects (Appendix B).

The teacher-researcher in this study met with the cooperating teacher in advance of beginning the study. He indicated that he would feel the most comfortable co-teaching Genius Hour with the teacher-researcher as he was not familiar with the Genius Hour technique. Prior to implementation with the students, the classroom teacher watched

videos explaining Genius Hour as well as examined student Genius Hour artifacts created by other students. The classroom teacher was interviewed before Genius Hour, several times throughout the process and at the culmination of the project. Additionally, students were given several instruments before Genius Hour to ascertain a baseline for future comparison. Students completed ranking tasks on their perceived science self-efficacy and the extent to which they see themselves as a scientist as well as rating their perceived abilities in the NGSS Science and Engineering Practices (National Research Council, 2016) (Appendix D). These instruments were administered again at the end of the Genius Hour project as well as two years later to the study sub-sample- the analysis and sampling procedure will be described later in this document.

Due to the lack of technology in the classroom, most Genius Hour classes took place in the library where there was a computer-student ratio of 1:1. During class meeting times students would conference with the classroom teacher or the teacher-researcher to ask questions and discuss progress. Additionally, every two weeks, students completed exit cards that detailed their progress to date, how they were feeling about the project and what they felt their next steps would be (Appendix E). At the end of Genius Hour intervention, each student presented an individual project in the form of a video or video with a live presentation to showcase their learning in the area of their choice and reflect on the Genius Hour process.

The instructional cycle for Genius Hour in the Physical Science classroom over the six week period was as follows:

Table 2. Genius Hour instructional cycle as implemented in a Freshman Physical Science Classroom.

Introduction Day: 10mins Teacher-Researcher introduces the concept of Genius Hour, shows inspirational videos on defining your passion, explains the assignment instructions and challenges the students to choose a topic before next Wednesday's Class
Week 1: Administration of Surveys, students communicate their topics and begin researching. Exit card completed. Research shared on Google Docs.
Week 2: Students continue researching. Research shared on Google Docs.
Week 3: Students continue researching. Research shared on Google Docs. Exit card completed.
Week 4: Students continue researching. Research shared on Google Docs. Students begin video component of their project.
Week 5: Research component complete. Students finish video component of their project. Exit card completed.
Week 6: Administration of Surveys, presentation of videos, culminating class interview. 3 classes to get through all the presentations.

Data Collection

Instrument Description & Administration Protocols

Data was collected before, during and at the culmination of Genius Hour from the full sample of 136 students. A sub-sample (n=8) was selected to take part in the longitudinal portion of the study spanning over two years. The sub-sample (n=8) was selected by the classroom teacher to be representative of the larger sample (n=136), and was comprised of high, average and low-achieving students. The sub-sample was chosen for the longitudinal study so that robust and thorough conversations could be recorded

and analyzed. Logistically, had the entire larger sample (*n*=136) taken part in the longitudinal interviews, depth of analysis would have been compromised. Some of the most effective qualitative studies dig deeply into a small number of participants instead of broadly surveying a larger population (Schunk, 2012). This technique often increases the specificity of observations about the phenomenon being studied (Schunk, 2012). Because Genius Hour is highly focused on the individual, their personalized experience and the transformations they undertake during and after the Genius Hour process (Juliani, 2014), a deep analysis into small sub-sample is better aligned to this phenomenon than a more superficial investigation of a larger number of participants. The administration timeline identifies the instruments and when they were collected from the students.

Table 3. Administration timeline for Genius Hour.

Before GH	During GH	Post GH	6 months post GH	18 months post GH	24 months post GH
• Analysis of existing GH resources • Identity and Self Efficacy Rating Scales • Science and Engineering Practices Rating Scale	• Exit Card Data Collection	• Class Discussion • Individual Interviews (n=8) • Identity and Self Efficacy Rating Scales • Science and Engineering Practices Rating Scale	• Individual Interviews (n=8)	• Small Group Interviews (n=3)	• Small Group Interviews (n=3) • Identity and Self Efficacy Rating Scales • Science and Engineering Practices Rating Scale • Analysis of Subsequent GH activities

Analysis of Existing Genius Hour Resources (pre-Genius Hour) Practitioner blogs, wikis, videos, webinars and books were reviewed prior to the study to

operationalize the fundamental foundations of the Genius Hour instructional technique in an attempt to couch it in an education theory as there are currently no peer-reviewed publications on this technique. Data was recorded and a thematic analysis was performed to identify logistical components of the technique, its educational goals and what was happening during the instructional technique from the perspective of classroom teachers. This analysis was a form of consensus building in an attempt to more clearly define Genius Hour practice and ensure researcher fidelity to the intended implementation and goals of this technique. After this initial operationalization was completed, the researcher developed an implementation strategy for Genius Hour in the study site that followed the elements of Genius Hour for which there was a strong consensus between the data sources. The researcher shared her findings with the classroom teacher prior to the introduction of Genius Hour to class to describe the instructional technique, its underlying principles, the role of the teacher, the role of the student and the goals for the project. Such an operationalization of the technique was necessary to ensure that the researcher was actually researching the Genius Hour phenomenon described by classroom practitioners (Krebs & Kirr, 2014), thereby promoting the validity of the research.

Identity and Self-Efficacy Rating Scales & Science and Engineering Practices Rating (pre & post Genius Hour) Students completed identity and self efficacy surveys (Appendix D) where they were asked to rate themselves on a scale of 1-10 on two questions pertaining to identity, one question pertaining to interest in science and one question pertaining to self-efficacy. All questions were discipline specific (science), for

example, ‘to what extent do you see yourself as a scientist?’ ‘to what extent do others see you as a scientist?’ Students were also asked to self-evaluate their proficiency in each of the Next Generation Science Standards Science and Engineering Practices. This instrument was administered to the sample of 136 students before Genius Hour, immediately following Genius Hour. The sub-sample completed a third administration of the instrument 24 months after Genius Hour.

Exit Card Data (3 collections during Genius Hour) Students were given exit cards at the end of the first, third and fifth Genius Hour sessions. The exit cards were given to students to complete in the last five minutes of the class and they answered three questions: What did you accomplish? What are your next steps? How do you feel about your project? Students that indicated they did not accomplish a lot or were feeling unsure of their project were asked to meet with the classroom teacher and the teacher researcher to talk through their roadblocks and problem-solve the next steps for their project.

Whole Class Discussion (immediately following Genius Hour) After the Genius Hour projects were showcased by the students, a whole class discussion was used to reflect on the process. Data was collected during these whole class discussions. The original interview questions were very broad so as to not influence the student responses (Appendix G). Students were asked what they liked about Genius Hour, what they didn’t like and any suggestions for improvement. An improvizational interview style was used and the researcher followed up on student responses and comments- cross talk was allowed where students would respond to other student comments. If students were not

responding the researcher called on them and asked them to share their thoughts. There was a participation rate of 90-100% of students in each class stating at least one comment in the whole class discussion. At the end of the 25 minute data collection, the researcher asked if there was anything anyone else would like to add or any comments said that other students did not agree with. These results were transcribed and each comment was tied to an individual student so that contextual influences could be analyzed.

Sub-Sample Individual Interviews (immediately following Genius Hour, 6 months post-Genius Hour) The sub-sample of 8 students was selected for the extended longitudinal study by the classroom teacher as a representative group of the typical demographics in the larger sample. There was an equal number of male and female participants selected. The science abilities of the sub-sample were reflective of the larger sample and comprised high, average and low achieving students. It is important to note that in this particular context, very high achieving students and students with exceptional learning challenges are placed in separate classroom environments so the range of abilities in the large sample (n=136) does not include these extremes in ability. Each interview had prepared questions and lasted approximately 20 minutes (Appendix F). The transcript from these interviews was later transformed into chart form that can be read by student or compare student responses for each individual question. Questions pertaining to identity and self-efficacy were examined for this study.

Sub-Sample Small Group Interviews (18 & 24 months post Genius Hour) The sub-sample of eight students experienced attrition due to factors such as student transfers

and graduation (n=3). The sub-sample was interviewed as a group where each student was asked to respond to interview questions (Appendix H) proposed by the researcher and cross-talk was allowed and tied to the student that provided the response. There was a natural interplay of the students elaborating and extending each other's responses. The order the students were asked the questions, changed for each question. At the end of the session students were able to express any additional comments they felt were not elicited by the researcher.

Analysis of Post- Genius Hour Activities & Artifacts (24 months post Genius Hour) The sub-sample students, at the 18 month post-Genius Hour data collection, were asked if they had done any activities since Genius Hour that were related to their Genius Hour project. Students provided links to social media accounts (YouTube channels, Facebook pages) so the researcher could analyze these artifacts and discuss these subsequent experiences (Appendix I). Students were also asked what these subsequent activities meant to them, what they represented and what their future plans are.

Data Analysis

All data collected from individuals was coded and students were given pseudonyms in written work to protect the confidentiality of the participants. The research study was started in October to ensure that the freshmen students had adjusted to the new high school context and the classroom teacher had familiarity with their individual strengths and weaknesses. Pre-treatment instruments were administered to create a baseline for comparison. The full sample of freshman physical science students

took part in Genius Hour and completed the Identity and Self-Efficacy Rating Scale and Science and Engineering Practices Rating Scale assessments (Appendix D). These students also participated in whole class discussions before the project and immediately following the project. While not every student participated in the whole class discussions, students were asked at the culmination if there was anything that was missed or if there was something that was said that they did not agree with and these additional comments were recorded. From the 136 student sample, eight students were selected as a sub-sample for more thorough and comprehensive analysis. The students selected were in regular science programming without Individual Education Plans or accommodations. The sub-sample consisted of an equal number of males and females. The sub-sample was selected by the classroom teacher to be representative of the larger population in terms of ability and demographics. The sub-sample was used in the longitudinal component of the study. A longitudinal approach was used to determine the saliency of the Genius Hour instructional technique and to give the students an opportunity to continue building parts of their identity developed by the project if they chose to do so. This analysis is useful because it allows the researcher to comment on the lasting influence of Genius Hour, if any.

To analyze the data, both horizontal and vertical comparisons were conducted. Horizontal comparisons compare different participants on any given measure and look for similarities and differences to ascertain emergent themes (Guba, 1994). In the sub-sample vertical comparisons were conducted where the various instruments for each individual participant are compared to determine if there is a consistent viewpoint

reflected in all instruments. Any discrepancies were noted by the researcher. Vertical analysis can increase the validity of any claims made by the researcher (Guba, 1994) and note for changes in individual participants. As identity development is a highly individualized phenomenon, vertical analysis was an effective strategy to document changes in the participants, especially the longitudinal sub-sample, over a long period of time.

Quantitative Data Analysis

This mixed methods study was primarily qualitative in nature; however, some quantitative measures were used to increase the validity and reliability of this study. Additionally, this information assisted the researcher in generating claims about the general trends occurring during Genius Hour. The quantitative data collected focused specifically on identity and self-efficacy in the science domain. A description of the analysis procedures for the specific quantitative instruments is described below.

Identity and Self-Efficacy Rating Scales & Science and Engineering Practices Rating (pre & post Genius Hour) All 136 students in the sample completed this instrument prior to the Genius Hour project and immediately after its' completion. Additionally, the sub-sample completed a third administration 24 months after the culmination of Genius Hour. A paired t-test was used to analyze the differences between the initial administration of these instruments and immediately following Genius Hour, p=0.05. A paired-t test analysis was chosen because differences in pre and post survey scores were calculated for the same group of students (Mills, 2010). Additionally,

student by student analysis was performed to identify which students had the greatest change over time, through a normalized gains test (Hake, 1998) and this data was compared with qualitative data collected. Additionally, effect size calculations between the pre and post administrations were used to comment on the relative strength of the difference in means on the ratings before and after Genius Hour. To calculate effect size in SPSS the ratings values for all responses were converted to percentages. Effect size statements were aligned with the accepted values of Cohen's d standards where 0.2 or less indicates a small effect size, 0.3-0.5 indicates a medium effect size and 0.8 or greater indicates a large effect size (Sullivan & Feinn, 2012). The similarities and differences between normalized gains scores, the paired t-test results and effect size calculations will be discussed in Chapter Four.

Qualitative Data Analyses

The qualitative component of this study was the predominant methodology used because qualitative techniques help to capture the richness of an experience (Schunk, 2012). It has been suggested in current research that identity construction is a compilation of the stories one tells one's self (Kapur, 2009). Therefore, it follows that qualitative measures may be the best approach to capture the lived experiences of the Genius Hour participants. A description the analysis procedures of each quantitative instrument are described below.

Exit Card Data (3 collections during Genius Hour) Exit cards were completed by students and collected after the first, third and fifth Genius Hour work periods. In each

exit card students had to answer what they accomplished, what their next steps were in their project and how they felt about their project (Appendix E). The first two questions were used logistically to address students needs and monitor progress while the third question was used for data collection purposes. The exit card comments were recorded and the number of similar statements was identified. After the initial tally, comments that had similar themes were grouped together and the number of times these comments appeared was recorded. This analysis was completed for the three administrations of exit cards and compared across time intervals to enable the researcher to comment on changing feelings over the course of the project. This data was represented in pie charts that show general categories.

Whole Class Discussion (immediately following Genius Hour) In the whole class discussion the researcher used exploratory questioning technique where the class discussion began with a solicitation of the students' thoughts and the researcher posed follow-up questions as they come up authentically. A transcript was created for each of the five sections of Physical Science and emergent thematic analysis was conducted (Appendix G). For particularly salient comments, information about the student as well as any additional contextual information was included to give the reader a more complete picture of the type of student a particular viewpoint was coming from. All thematic statements generated by the researcher were validated by each participant by asking if they believed the statements were accurate and complete.

Sub-Sample Individual Interviews (immediately following Genius Hour, 6 months post Genius Hour) The sub-sample consisted of eight students and each was interviewed individually with structured interview questions. This information was compiled into a chart (Appendix F) so that the responses for each participant could be compared (vertical analysis) as well as a comparison between the participants (horizontal analysis) and a thematic analysis was completed. Special attention was paid to comments with emotion words to compare these comments to the theoretical framework of Dewey's Interest Theory (Dewey, 1910) as well as any statements that refer to the underpinnings of the Hybrid Identities/Third Space Theory (Gutierrez, 2008). All thematic statements generated by the researcher were validated by each participant.

Sub-Sample Small Group Interviews (18 &24 months post Genius Hour) The remaining sub-sample consisted of three students as other participants in the sub-sample were lost due to attrition factors such as student transfers and graduation. The interview was conducted as a group with each student given an opportunity to answer each question. The transcript was arranged by each student's comments to retain the 'authorial voice' of each particpant. Responses were compared to the historic responses provided by each participant as well as a horizontal cross comparison to determine if there were any changes in the students' responses over time. All thematic statements generated by the researcher were validated by each participant.

Sub-Sample Analysis of post- GH activities (24 months post Genius Hour) The sub-sample group was asked to discuss how Genius Hour influenced their subsequent

activities. The remaining sub-sample (*n*=3) had created artifacts such as videos, blogs and participated in clubs, groups and events based off of their original Genius Hour project (Appendix I). A qualitative analysis was conducted where each artifact was analyzed through the lens of identity and self-efficacy. These subseqent artifacts were compared to the original Genius Hour artifacts and the differences were noted. After the researcher generated comments, they were validated by the participants.

Triangulation was achieved by requiring the students to answer numerous questions and participate in many different tasks (ratings, group discussion, individual interviews, small group inteviews). The task variety and repetition was used to increase validity by analyzing the degree of congruence between an individual's responses, before making cross participant comparisons. Comparative analysis was completed by creating a transcript chart to determine themes. All summaries and themes proposed by the researcher will be validated by the respondents and discussed with the participating teacher. The quantitative data was obtained from a large sample (*n*=136) and a p-value of 0.05 indicated that the results of the paired t-tests suggest that differences are likely due to some factor. The mixed methods approach increased the potential generalizability of the findings if there is similarity between the data sources. The longitudinal aspect of the Genius Hour study also increased the number of data sources to determine if any of the changes seen were stable over time.

A mixed methods approach was used in this case study in an attempt to increase the accuracy of the claims made by the researcher. As Genius Hour has no established research protocols due to the relative absence of peer-reviewed sources, a wide variety of

data sources may more accurately document the phenomenon and provide a stronger basis for subsequent research. The validity of and reliability of the quantitative data gathered in this study were addressed through a variety of strategies including a large sample size (n=136), multiple administrations of the exit card (three administrations) throughout the Genius Hour project and complementary statistical analyses. Three statistical analyses were peformed for each set of Likert rating scales including, paired sample t-tests, normalized gains and effect size. Taken together results can be established with some degree of certainty whether or not the results were significant and the degree of influence of Genius Hour on the student responses. To address the conditions of trustworthiness the researcher obtained qualitative data from a variety of sources at a variety of times, under a variety of circumstances. For example interviews occurred as whole class discussions, individual interviews and small group interviews, with some of these measures spanning two years. Additionally, both written and oral responses were collected during numerous times throughout the study period. All qualitative responses were validated by the participants in the study. In the following sections strategies used to address reliability and validity for the quantitative data and strategies used to address trustworthiness and credibility for the qualitative data are expanded upon.

Validity & Reliability

There were several measures taken in this study to address validity; however, the absence of study protocols, validated research instruments and a limited body of

knowledge regarding the instructional technique of Genius Hour presented challenges. To increase validity, the researcher performed an investigation of the existing Genius Hour publications and performed a cross-comparison to identity similarities and differences. If practices and descriptions were similar across many sources, these components and characteristics were identified as integral parts of the Genius Hour instructional technique. Operationalizing Genius Hour prior to beginning the study with participants increased validity of the findings because there is a high degree of congruence between the phenomenon as described by practicing teachers and the instructional technique implemented in the study site. Additionally, there was a great deal of alignment between the characteristics of the phenomenon being studied and the method chosen to record observations. For example, a lot of identity research is anchored on the idea that identity is a construction of personal narratives or how one makes sense of the happenings in one's life (Kaplan & Flum, 2012) and the study used an open ended conversational interview style to elicit these stories from participants in an authentic way. The more open ended interview style limits the researcher's inadvertent editing of the authorial voice of interviewees (Schunk, 2012), thus increasing internal validity.

Another way the study attempted to increase validity is through the use of simple language on instruments to promote understanding by students of all abilities (Schunk, 2012). Questions such as 'I see myself as a scientist' have few words and simple vocabulary, thereby limiting possible misinterpretation. Additionally, a large variety of data sources was used to attempt to triangulate the results by noting the similarities and differences between instruments. As indicated earlier, a vertical analysis of results was

performed where all data collected for an individual was compared to note the degree of congruency between responses across various time intervals. The high degree of consensus between individual's responses over a period of two years in the longitudinal sub-sample is perhaps the strongest case aspect of this study.

External validity for this study is limited as there were no known peer-reviewed articles regarding Genius Hour at the time of this study. Identity is also an emerging field and is predominantly studied using qualitative methods (Klos, 2006) which often do not address generalizability concerns as well as qualitative data. While this study was predominantly qualitative to fully capture the richness of the participants' experience during Genius Hour, quantitative data from pre and post rating scales were analyzed using comparisons of paired t-test, normalized gains and effect size with the accepted p-value of 0.05. The results generated from these statistical tests may provide initial foundations when larger studies of Genius Hour are performed across different contexts. It is important to note that as this study was an exploratory case study; its nature is to be more concerned with internal validity because the study is bound to a single context (Schunk, 2012). Exploratory case studies are often the first types of 'pioneering research' in emergent fields with the goals of clarifying and operationalizing a phenomenon and making tentative claims (Schunk, 2012). Later studies can build on this initial research and perform cross comparisons which can better address external validity and generalizability (Schunk, 2012).

Reliability in this study was addressed by administering the same instruments at different time intervals. For example, the same self-report surveys were administered

before the start of the Genius Hour intervention and at its culmination. Similarly, exit card data was obtained at three different time intervals throughout the project. In terms of qualitative data, reliability was addressed by interviewing the students in the sub-sample six, 18, 24 months after the culmination of Genius Hour. The students were also asked to review their previous statements to uncover any inconsistencies and ensure that the researcher's portrayal of their thoughts was fair and accurate. Greater reliability of the instruments used in this study could be achieved through a greater number of administrations.

Credibility & Trustworthiness

To address the criteria of *credibility*, the researcher was immersed in the study as a teacher-researcher to provide support to the regular classroom teacher in implementation of this project. While familiarity can evoke certain biases in the research participants (approval seeking) (Schunk, 2012), it can also create a degree of comfort that elicits candidness during the interviews (Patton, 2001). The researcher has implemented the Genius Hour instructional technique in K-12 and post-secondary environment for five years and has deep familiarity with the technique.

Dependability was promoted in the open inquiry process during the interviews. Subsequent questions and clarifications will be sought in addition to asking the participants if there was anything they would like to discuss that was not asked by the researcher. This study assumes participants honestly answered questions and their articulated thoughts were representative of their experience. This study design promoted

objectivity regarding the Genius Hour experience through the longitudinal data collection by the six month,18 month and 24 month data collection periods after the culmination of the project. Consistency of individual responses across time intervals increases the internal validity of the data. Additionally, a pre-study analysis of available Genius Hour documentation and publications was performed and themes were identified to ensure the instructional technique implemented in the study was consistent with the practices of other teachers. This step was necessary due to the absence of formal studies on Genius Hour.

Transferrability was addressed through the use of direct student quotations rich in context and individual perspective. It is assumed that the most salient aspects of the experience are the ones that persisted in the students' memories. *Confirmability* will be achieved through data collection, where all data associated with a participant was labeled as such. Data will be analyzed in terms of the individual participant (all instrument types related to the individual were analyzed which also increased internal validity by highlighting inconsistencies) and the group (thematic analysis of interview data to increase generalizability).

Limitations

The major limitation of this study is that it is a pioneering enterprise; there is not an established research base for Genius Hour and all findings of the study will be tentative. Additionally, the approach taken is exploratory into the many features of

Genius Hour to establish the general educational topography of this instructional technique, rather than being a probing investigation into a contained phenomenon.

The sub-sample size involved in the longitudinal study component varied between three to eight research participants. The variance is due to a number of factors including, but not limited to, student transfers, graduation and scheduling conflicts. To mitigate this issue, there is mixed methods data from the entire sample of students (n=136) documenting conditions before the Genius Hour intervention and after its completion as well as several qualitative snapshots involving the original sub-sample of eight students. Only the last two data collection periods saw a significant decrease in the number of participants, however, the numerous data snapshots over the two year period attempted to capture the depth of individual student experiences.

Another possible limitation is the students' lack of familiarity with the Next Generation Science Standards Science and Engineering Practices (National Research Council, 2016). At the time of the study, neither the state, nor the high school had adopted NGSS. Students in the study were not familiar with evaluation based on the Science and Engineering Practices (National Research Council, 2016) and this may have influenced their self-reported proficiencies for each of the practices. It cannot be determined if their perceived competency was over or under-represented or accurately represented. One could only assume that accuracy in the self-evaluations would be improved if students had an ongoing assessment dialogue with their teachers and peers in the language of the Next Generation Science Standards (National Research Council,

2016). Of important note, however, is the simple language in which the Science and Engineering Practices are communicated.

Assumptions & Rationale

The researcher assumed that all participants in the study were open and honest in their comments regarding Genius Hour as there was no extrinsic motivation to participate in the research study such as an increase in grades. Additionally, the researcher assumed that all participants possessed the necessary vocabulary and communication skills to accurately describe their experiences in qualitative measures. In regards to quantitative measures, it is assumed that the students' self-evaluations of their science identity ratings, self-efficacy ratings and Science and Engineering Practices ratings (Appendix D) were evaluated using the same personal standards at each data collection interval so that relative distances accurately reflect the influences of the educational intervention. It was assumed that despite the students in this sample not having a great deal of experience using the Science and Engineering practices, they would still be able to self-evaluate on these measures because of the simple and straightforward language of each practice put forth by the National Research Council. Finally, the most important assumption of this study is that the longitudinal nature of the study will capture any lasting influences of Genius Hour as seen in any lasting or newly emerged behaviors in response to the project.

The rationale for doing this study was the research gap on the instructional technique of Genius Hour and its strong following among educators. The use of a

longitudinal approach allowed the researcher to comment on the lasting influences of Genius Hour and to more accurately describe the relative strength of the influence on identity and self-efficacy. The gains recorded immediately following an intervention may fade, stay the same or be amplified over time. By collecting data at set intervals over a two year period, the researcher was better able to comment on the saliency of this instructional technique and capture the individual trajectories of students in the sub-sample.

Positionality Statement

The teacher-researcher in this study has 10 years of teaching experience teaching all grades from kindergarten to masters' students, in a variety of disciplines, primarily science, with two years administrative experience. The researcher has taught in Canada, Australia and the United States, in a wide variety of school settings, from rural, multi-graded farm schools of 38 students in K-9, to urban magnet schools with student populations of 2500 students. In 2012, the teacher-researcher was selected to pilot the Genius Hour instructional technique with students in grades three through five as part of instructional leadership capacity building to support teachers in Alberta as the province went through major educational reforms in the Inspiring Education Movement. The direction for the educational reform was determined by a large-scale Delphi study which included input from all stakeholders such as business, industry, post-secondary institutions, teachers, students, parents and school board members and included a three pronged vision for student success. The three primary goals for teaching in Alberta

emerged as student engagement, developing the entrepreneurial spirit (innovation, creativity, risk-taking, development of transferrable skills) and ethical citizenship. Anecdotal evidence and practitioner tips for implementation were gathered by the teacher-researcher and communicated to the science teachers of Prairie Rose School Division in the form of professional development in her role as Science Council Chair.

In subsequent years, the teacher-researcher performed Genius Hour with high school students as well as education undergraduate students taking Science Methods. This long immersion in the instructional technique allowed the researcher, when conducting formal research, to concentrate wholly on student experiences rather than the execution of the instructional technique. Experiencing Genius Hour across so many grade levels in so many different teaching environments enabled the researcher to separate the educational experience of Genius Hour from contextual factors and identity cross-cutting trends. When the results of the formal research in this study were compared to anecdotal knowledge the teacher-researcher has been gathering over the years, the researcher reflected upon her earlier constructions of the phenomenon and noted areas of confirmation and variance. While the extended degree of familiarity of the teacher-researcher with Genius Hour may promote bias, it also enabled a deeper exploration of the phenomenon; subtle nuances were more easily identified through eyes that have been observing a long time.

Summary of Chapter Three

Chapter Three discussed how the researcher operationalized Genius Hour in the absence of peer-reviewed formal research on this instructional technique through the examination of anecdotal resources from practitioners and then described the technique that emerged from the characteristics in which there was consensus across resources. This technique was implemented and its influence on identity and self-efficacy was studied using a mixed methods approach with a qualitative emphasis. The selection of the sample and the sub-sample for the longitudinal portion of the study was described as well as the merits and limitations of the study design taking into account the contextual factors. The aim of the research was to clearly define Genius Hour, and comment on students' individual experiences throughout the project as well as describe any long lasting influences on identity and self-efficacy.

RESULTS

Overview

The purpose of this study was to examine the influence of a Genius Hour intervention on identity and self-efficacy for students in a high school physical science class. More specifically, the researcher designed a two year, mixed methods, longitudinal, exploratory case study to determine how the Genius Hour instructional technique might influence identity formation and self-efficacy. Five classes of ninth grade physical science students (n=136) participated in the initial stages of the study. It is important to note that none of the students in this sample, nor the classroom teacher, had any previous experience with the Genius Hour instructional technique. For this reason, the researcher co-taught Genius Hour with the participating classroom teacher. The researcher described the teaching technique to the classroom teacher after the operationalization of Genius Hour was completed by the researcher. After the classroom teacher had a more firm understanding the pedagogy associated with the Genius Hour instructional technique, the researcher introduced the project to the class and assisted the classroom teacher in monitoring student progress and facilitating the final presentations. It is important to note that prior to beginning the classroom implementation of this study, permission was sought from the school district, principal, participating teacher and the Institutional Review Board (Appendix J). Additionally, letters were sent home describing the project and the students' role in the project as well as the data collection strategies that would be used.

At the culmination of the Genius Hour intervention, each student developed a short 5-minute multimedia-based video of their project, and shared those videos with the whole class in an effort to communicate their Genius Hour work with their peers. The video format was an essential component of Genius Hour because it increased the dissemination of the students' work to a larger community. In addition to their videos, some students included musical performances or demonstrations during their presentation to the class. In their presentations, students highlighted findings from their project, reasons why they were passionate about the topic, and how the experience changed them. Each presentation culminated with a question and answer session with their classmates.

Following the initial stages and data collection, which took place during the intervention and immediately after the students' final presentations, a sub-sample students (n=3-8), was selected and from whom quantitative and qualitative data was collected throughout the two years following the Genius Hour intervention. The sub-sample was chosen by the classroom teacher to be representative of the student population in terms of ability and demographics. The sample was composed of two high achieving students, four average achieving students and two struggling students. This purposeful selection was based on the teacher's appraisal of the students' scientific ability based on their performance in physical science prior to the Genius Hour intervention. It is important to note that at high school where this case study took place, gifted and talented students as well as students with special needs, receive special programming and such students were not present in the classes selected for this study. One student in the sub-sample selection was a non-Caucasian student which made the sample slightly more

ethnically diverse (87.5% Caucasian) than the demographics in the municipality (94% white). The sub-sample participated in periodic data collection for two years. The majority of the data was qualitative in nature. The focus on qualitative data was intended to capture the richness of individual experience of the students which aligns with the value of individualism in the Genius Hour instructional technique.

A presentation of the findings is organized by emergent theme in Chapter Four and categorized into the two main areas of study, identity and self-efficacy. Within each theme, applicable qualitative and quantitative data will be discussed. In Chapter Five the interpretation of the results is organized into eight themes under the principle topics of investigation, identity and self-efficacy.

Review of Data Collection Process

The first part of this study included an extensive review of a wide variety of practitioner sources which described the Genius Hour process. Considering little to no scholarly work existed regarding Genius Hour, the researcher wanted to ensure that operationalizing Genius Hour was couched in practitioner perspectives of the technique and grounded in practice. This review process contributed evidence of construct validity because the phenomenon of Genius Hour in this study aligned with the practice of other teachers and authors. Commonalities between a variety of sources was established culminating in a more precise description of this technique. This resulting Genius Hour definition was then used to frame this entire study.

Once Genius Hour was operationalized by the researcher, the technique was implemented in five class sections of physical science belonging to a single classroom teacher. All students in each of the five classes participated in Genius Hour over a six-week period (n=136). Data was collected from the sub-sample (n=3-8) of students for two years after the culmination of Genius Hour. The longitudinal component was explored to determine the lasting influence of Genius Hour, if any.

It is important to note that the researcher in this study co-taught the students in this study because the participating classroom teacher had no previous experience with this technique. The researcher introduced the Genius Hour project, assisted the participating classroom teacher in the approval of project topics, provided formative feedback to students throughout their projects, assisted in the monitoring of student progress and facilitated the students' presentations. The researcher also answered any questions that the participating teacher had and shared pedagogical approaches so as to adhere to the operationalized characteristics of Genius Hour with fidelity. Additionally, the researcher administered instruments and collected quantitative and qualitative data before, during and after the culmination of Genius Hour.

Data collection during the intervention focused on qualitative and quantitative data sources and was collected before, during and after the intervention. Quantitative data sources included surveys on identity, self-efficacy and self-appraisal of competence in each of the eight Science and Engineering Practices as described in NGSS (National Research Council, 2016). Qualitative data sources included written comments on exit cards throughout the process, individual interviews, small group interviews and whole

class discussions. The array of data collected during was an attempt to capture different facets of the complex instructional technique of Genius Hour and the intricacies of identity and self-efficacy. Data was collected in a wide variety of formats to ensure students with different abilities could express their experiences. After the original Genius Hour implementation, longitudinal data was collected from the sub-sample (n=3-8) over a two year period. The longitudinal data collection focused predominantly on interviews at different time intervals over the two years, as well as re-administration of the original quantitative assessment of identity, self-efficacy and student perception of their Science and Engineering Practices (National Research Council, 2016)

Table 4 summarizes the data sources, the method of collection and brief description, and logistical information such as the timeline and the logistics. A more comprehensive and detailed description of each instrument and its subsequent analysis procedures is found in Chapter Three.

Table 4. Summary of Data Collection.

Data Sources	Method of Collection & Description	Timeline and Logistics
Available sources on Genius Hour	Search of electronic and book sources on Genius Hour	Prior to classroom implementation of project
Pre and post quantitative data for identity, self-efficacy and Science & Engineering Practices	Numeric self-report rating scales	Whole class (*n*=136) before and immediately following Genius Hour, sub-sample 24 months after Genius Hour (*n*=3)
Exit cards	Written recipe cards where students reflected on project progress and how they felt about their project	Whole class, completed the last 3 mins. of every Genius Hour class period
Whole Class Discussions	Open investigative, conversationalist interviewing	Whole class, immediately following Genius Hour presentations
Individual Interviews	Pre-established questions	One week after whole class discussions, Sub-sample (*n*=8)
Small Group Interviews	Pre-established questions and conversationalist interviewing	Recurrent interviewing at 6 months, 12 months and 24 months after Genius Hour, Sub-sample (*n*=3)*
Examination of Genius Hour artifacts	Analysis of the videos of Genius Hour projects	Immediately following Genius Hour, Sub-sample (*n*=8)
Examination of activities and products following Genius Hour	Analysis of students' activities including subsequent videos, YouTube channels and further learning opportunities	Performed 24 months after Genius Hour, Sub-sample (*n*=3)

*sub-sample size decreased due to attrition (moving, graduation, scheduling conflicts).

It is important to note that the sub-sample size fluctuated over the course of the study; however, the three consistent participants were present for all interviewing

intervals which is important in documenting their individual experiences and growth after the completion of Genius Hour. Vertical analysis of all the data sources pertaining to each individual was examined to in an attempt to create a complete narrative describing individual student experiences. Additionally the emergent themes from the sub-sample were horizontally compared to other qualitative data with larger sample sizes such as whole class discussions to address generalizability.

Data Analysis

Operationalizing Genius Hour

At the time of this study, there were limited resources regarding Genius Hour and a relative absence of Genius Hour in peer-reviewed studies, suggesting a research gap for this instructional technique. However, there were several practitioner directed resources available in print and online. These resources were examined and commonalities were identified between the sources to form a consensus on the Genius Hour technique and attempt to formally operationalize this technique.

Information about Genius Hour was gathered, analyzed thematically and organized into the following themes: role of the teacher, the role of the student, the project description, educational goals and perceived outcomes. Each source was put into a chart with the theme headings and then each column was analyzed to look for commonalities. The available resources had varying viewership. Because a description of a phenomenon is most accurate when it reflects the reality of the greatest number of people participating in it (Schunk, 2012), the researcher weighted the sources by their

audience size. For example, the most popular Genius Hour instructional video on YouTube has 292, 368 views. As a result, the YouTube instructional video was given greater weight than a blog page with 1000 visitors. For example, if a discrepancy in the description of the Genius Hour technique existed between the instructional video and the blog, the description in the video was used in the description of Genius Hour because the video had a greater following. For a fair comparison of print resources, the Best Sellers Rank on Amazon, which states the number of copies sold, was used to determine the relative audience size of each book. Cross-media comparisons were made under the assumption that print resources had greater weight than online sources because they endured some form of peer-review.

Additionally, Wettrick (2014), Juliani (2014), Krebs (2015) who each published books on Genius Hour, had previously published online resources that were initial conceptions prior to their print resources. The degree of consensus between sources was described by the researcher to communicate the aspects of the Genius Hour instructional technique teachers should have the greatest fidelity to and which aspects are more customizable to their specific teaching contexts. This information is summarized in Figure 1. The operationalization of Genius Hour was the first step in this study to increase the validity of the findings of this study and the reproducibility of further studies of Genius Hour.

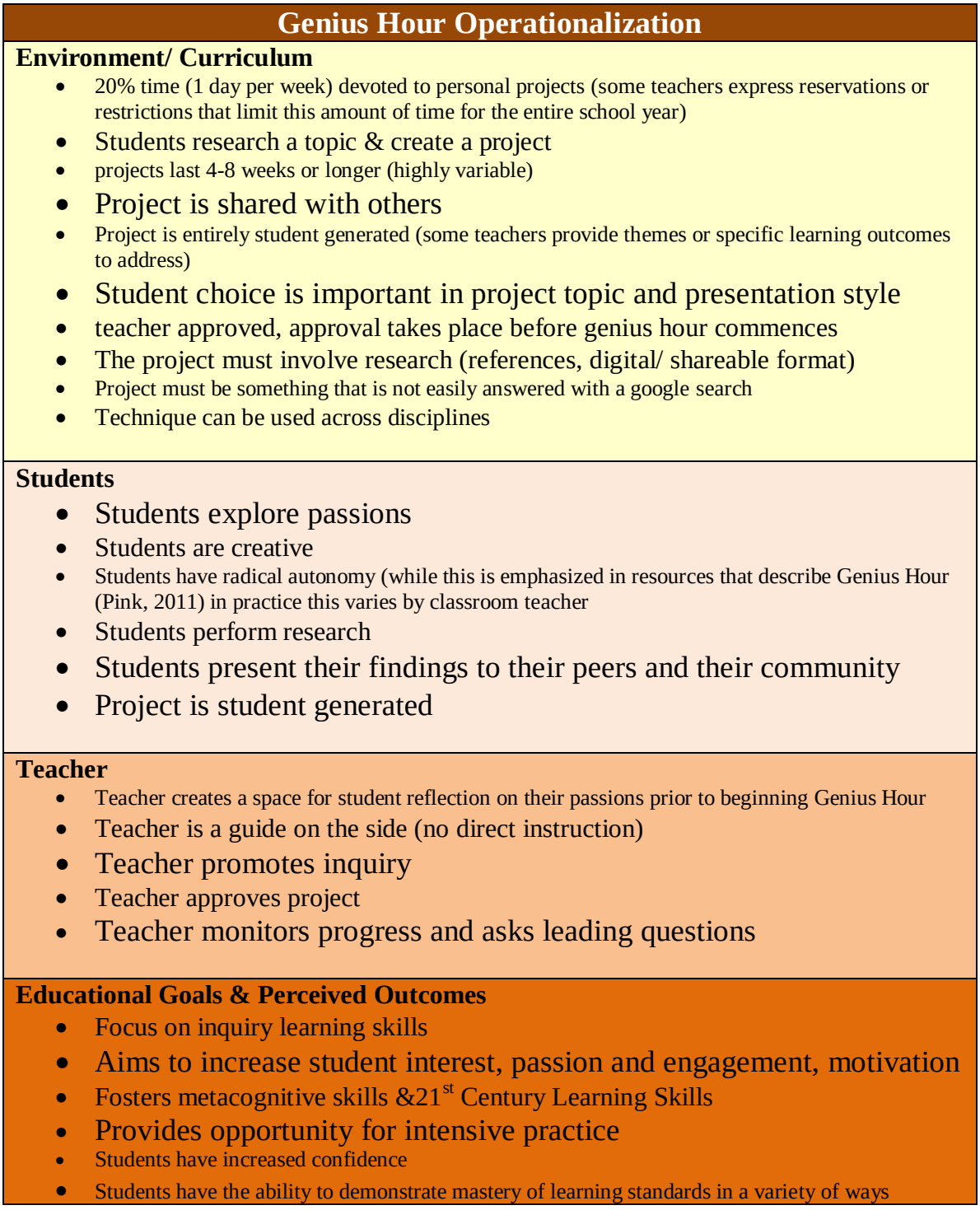


Figure 1. Infographic representing the operationalization of Genius Hour.
*Font size indicates the relative consensus among available resources at the time of the study (2016) with larger font indicating a strong consensus among Genius Hour artifacts.

Findings to operationalize Genius Hour through a review of the available literature suggested the greatest consensus among educators practicing Genius Hour is the importance of student passion and purpose. The most popular instructional video on YouTube describes Genius Hour as a place "where passions come to life" (Kesler, 2014). The vast majority of comments in teachers' blogs and wiki spaces describe anecdotal observations of students being "on fire for learning", "completely engaged", "excited for learning" (Krebs & Kirr 2014). These observations were predominantly in the affective domain with some educators reflecting on their own Genius Hour experience using predominantly emotions-based vocabulary rather than cognitive describing words (Krebs & Kirr, 2014). Available print resources on Genius Hour discussed practical strategies to increase engagement and purpose, such as giving students surveys to find out what interests they have (Juliani, 2014; Wettrick, 2014), practicing self-reflection (Krebs & Zvi, 2015) and providing leading questions (Krebs & Zvi, 2015) to help students discover their passions. Practicing teachers across disciplines as well as the authors of the Genius Hour books, emphasize the importance of providing enough time for students to select a topic they are really invested in (Krebs & Zvi, 2015). 'Purpose' is the pillar of Pink's motivation discussion (2011) that this study found educators had the greatest fidelity to in their practice.

Operationalization of Genius Hour, through a review of the available literature, also suggested that identity formation might result from Genius Hour interventions. As indicated in the review of the literature in Chapter 2, Erikson (1969) recommends that one's purpose is a component of self-actualization construct and requires intimate

knowledge of one's identity (Faircloth, 2012). The practice of choosing a topic in Genius Hour requires self-knowledge and self-reflection (Juliani, 2014) and an interaction between a student's identity and school. This study's examination of practitioner accounts of Genius Hour revealed students as young as kindergarten were able to identify a personal purpose such as 'helping the earth' (Krebs & Kirr 2014).

Elements of 'autonomy' also emerged during the Genius Hour operationalization efforts. 'Autonomy' is described as having a control of over one's destiny and leads to greater creativity and ownership and investment in one's work (Pink, 2011). This pillar had the greatest variability among practicing teachers and showed signs of the greatest modification in individual classrooms in the survey of Genius Hour resources performed in this study. Some teachers provided highly specific, content-specific curricular outcomes that students were required to address in project form (Krebs & Kirr 2014), while others held to the more purist line of "radical student autonomy" (Kesler, 2014). Other implementation strategies included providing students general themes or co-constructing criteria with students regarding their individual projects (Juliani, 2014; Krebs & Zvi, 2015). The more formulated resources, primarily webinars and books (Wettrick, 2014; Juliani, 2014; Krebs & Zvi, 2015; Kessler, 2014), suggest that standards based assessment, where assessment is based on demonstration of a skill or knowledge rather than a specific artifact, such as a test, aligns well with Genius Hour. In the examination of Genius Hour resources performed in this study, the major hesitation expressed by teachers unwilling to embrace 'radical autonomy' was an anticipated loss of classroom behavioral control (Krebs & Kirr, 2014; Juliani, 2014). Research on

educational motivation suggests this anticipated link between radical autonomy and off-task behavior is unfounded as numerous studies link greater student autonomy with increased engagement and time on task (Brophy, 2004; Lee, 2007). In relation to the study performed by the researcher, radical autonomy was followed with fidelity in the case study. An interesting finding in the review of Genius Hour practitioner accounts was that teachers of certain disciplines found the radical autonomy component of Genius more challenging than others (Krebs & Kirr, 2014). Elementary teachers, English and Fine Arts teachers tended to allow for the greatest openness of expression, while Science, Mathematics and Senior high teachers appeared to delineate the parameters of the Genius Hour projects, therefore compromising 'radical autonomy (Krebs & Kirr 2014). It is unclear if it is the curriculum these teachers must teach or the personalities of the teachers who teach these subjects that accounts for hesitation in embracing more student-centered instructional techniques. While this study was performed in a science classroom, the relative broadness of the Science and Engineering Practices (National Research Council, 2016), as compared to specific content standards, enabled students a greater selection of research topics, therefore promoting student autonomy.

In the review of teacher blogs, teachers noted that when students are given the radical autonomy to make all learning choices, these choices can reflect their individual values and personality traits (Krebs & Kirr, 2014). Autonomy encapsulates individualism and agency (Brophy, 2004). Findings from this study suggest that there were recurring statements which indicated Genius Hour projects can extend from a demonstration of learning to a demonstration of who each individual student is (Krebs &

Kirr, 2014). In blogs and wikis, teachers commonly stated that the project enabled them to know their students better (Krebs & Kirr, 2014).

The review of the literature also indicated that practitioners indicate 'mastery' is a component of Genius Hour. If mastery is considered a deep-immersion into learning that is afforded substantial time and effort (Brophy, 2004), the fidelity of teachers to the concept of mastery varied greatly in the resources examined by this study. Some Genius Hour projects were given as much as 20% time for an entire year as students explored a single topic of study, while others were given as little as three weeks (Krebs & Kirr 2014). Some classrooms had a dedicated 20% time throughout the entire year with students choosing as many projects as they wanted, with project culmination determined by a sense of completion by the student, rather than a timeline directed by the teacher (Krebs & Kirr 2014). This format was more often occurring in elementary and middle school classrooms than in the high school environment (Krebs & Kirr, 2014).

In summary, the operationalization of Genius Hour aimed to provide a clear description of the phenomenon occurring in classrooms by describing areas of consensus among practising teachers. Additionally, the areas of disagreement were noted to describe components of the technique that showed the greatest modification by teachers to meet their classroom needs. Chapter Five will explore how each of Pink's motivational pillars (2011) relates to identity and self-efficacy during the Genius Hour instructional technique.

Quantitative & Qualitative Analysis

The quantitative sources of data for this study included pre and post surveys pertaining to science identity and science self-efficacy (Appendix D). Additionally, students provided pre and post self-assessment scores for their perceived abilities for each of the eight Science and Engineering Practices (National Research Council, 2016). These quantitative data were collected from the full sample of students (n=136). Statistical analyses included paired t-tests, normalized gains and effect size calculations.

The qualitative sources of data for this study included written comments on exit cards collected three times, every other week, during the Genius Hour project, as well as class discussions, small group interviews and individual interviews after the culmination of the Genius Hour project. A sub-sample of students (n=3-8), was followed for two years in the longitudinal component study and interviewed in a small group format. The qualitative data was sorted into the two major categories of identity and self-efficacy with emergent themes pertaining to each category discussed. Emergent thematic analysis was performed by vertical comparisons of individual student responses over time and comparisons between students.

Data analysis from both qualitative and quantitative sources resulted in two major emergent themes, and sub-themes within those dimensions that can be used to frame the study's findings. In the following sections, these themes will be explored in depth. It is important to note that these themes resulted from both qualitative and quantitative data and can be sorted into the major headings of identity and self-efficacy.

Overview of Findings as Related to Research Questions

How does Genius Hour influence identity and self-efficacy in high school science students? Qualitative comments and emergent thematic analysis revealed that the components of Genius Hour related to identity development were the motivational factors of 'autonomy' and 'purpose.' Self-reflection and metacognition in the selection of a topic appeared to activate existing components of student identity as revealed by comments in interviews and class discussions. Additionally, the narratives between students and their peers and family regarding their Genius Hour projects were indicated as contributing to identity formation. Students consistently indicated they experienced feelings of pride in their work and validation from peers, family and the larger community during the presentation of their project and this altered their sense of self; greater self-confidence, increased self-worth and acceptance of uniqueness. "Sarah" said she "felt shy about [her] singing ability until [she] presented to the class and everyone liked her performance." Students also revealed a strong connection between the degree of ownership they had over their project, their level of commitment to it and the amount of pride they felt in their work. Most students indicated they both prioritized Genius Hour over other tasks and "devoted substantially more time to it than other school work because it was enjoyable" and a time and space in their personal lives was already established for pursuing their passions. This finding suggested the 'mastery' component of Genius Hour, promoted by the allocation of 20% time to the project, promoted feelings of self-efficacy. The students in the longitudinal study revealed that their participation in Genius

Hour developed skills in them that they have applied in later activities, specifically skills such as time management, problem solving, resilience and self-reliance.

How does Genius Hour influence science identity? Qualitative data indicates that students' science identities were influenced by Genius Hour revealing that science existed in activities that were already established components of who they are as individuals. The establishment of the 'third space' (Guiterrez, 2008), where personal interests and academic knowledge intersect, appeared to not only occur in the classroom, but in the homes of students through their conversations with family and friends. Qualitative comments revealed that the examination of existing interests through a scientific lens altered the way they experienced subsequent phenomena in the world around them. "Guy" said that he "realized science was everywhere after Genius Hour." While there were no statistically significant gains to students' ratings of "I see myself as a scientist" and "Others see me as a scientist", qualitative comments revealed that students did experience a conceptual shift. This shift was most apparent in the longitudinal sub-sample where some students altered their future career paths based on their participation in the Genius Hour project.

How does Genius Hour influence science self-efficacy? Findings from qualitative data in this study also suggested that science self-efficacy was developed by students reconceptualising what it means to be a scientist and identifying existing strengths and aptitudes in themselves that are characteristics of scientists. In interviews students also revealed that they spent substantially more time working on their Genius Hour projects, providing more time for the mastery of skills. "Cole" indicated he "spent more time on

Genius Hour and prioritized above all other tasks because it was enjoyable." Quantitative analysis revealed that there was a statistically significant gain in students' self-rating on the statement "science is something I am good at", with marginal, but statistically significant gains seen in the Science and Engineering Practices of "asking questions and defining problems" and "analyzing and interpreting information (Tables 9, 10). In exit card data obtained at three different intervals during the Genius Hour project, students revealed increasing levels of feelings of competence as the project progressed (Figure 2). Additionally, students in the longitudinal study continued to pursue scientific endeavours related to their Genius Hour project, two years after its culmination, thereby continuing to operate in mastery learning.

Detailed Analysis of Emergent Themes

Identity Themes

Identity is the pattern of thoughts and behaviors unique to each individual (Dewey, 1910). Identity formation occurs when individuals make sense of their experiences and interactions with others through the stories one tells oneself (McLean, 2015). The following identity sub-themes emerged during the study of the Genius Hour intervention.

Theme 1 Self Reflection Opportunities. One identity theme that emerged from the qualitative data sources in this study was that students were performing self-reflection during and after Genius Hour. During Genius Hour students evaluate and modify their project based on their own self-reflection and input from peers, family and the

community (Juliani, 2014). For the purposes of protecting student confidentiality and privacy, participants have been assigned pseudonyms and those pseudonyms are used in the following analyses. When asked to describe a strength of Genius Hour, "Ava" stated, that "there were no boundaries" and it "allowed us to focus on our own goals we set ourselves". "Leon," who created a project on the science of the guitar, noted several differences between traditional classroom tasks and Genius Hour when he stated:

> In a traditional classroom it is laid out what and how you are supposed to learn something, whereas with Genius Hour, the project was to the expanse of your imagination- there was no point where I was confused- my standards were different than the person next to me. In doing that I was able to experiment with different ways to present- I've been able to create podcasts and YouTube videos and present information better than before. We judge knowledge based on criteria laid out for us- people may know things in different areas, knowledge isn't confined to writing papers- it is what you know and how you apply it.

During participant validation, "Leon" summarized this quote by proposing that the autonomy to express his uniqueness through his selection of personal standards of quality allowed him to be creative and innovative in his pursuit of knowledge.

Theme 2: Cultivation of Passions & a Charged Emotional State. Genius Hour is described in instructional videos as a place "where passions come to life" (Kesler, 2014). In this case study students were taught about the principles of Genius Hour and asked to reflect on their personal passions. Students were given a week from the time the topic was introduced to select a topic for their project. Prior to the implementation of the Genius Hour project students were asked to rate themselves on simple statements regarding their feelings towards science in an attempt to address the domain specific research question of this study (Appendix D). Data was collected after the immediate

culmination of the project. Qualitative data in the form of interviews and class discussions was also collected.

There is an established research basis that indicates student enjoyment and positive feelings are positively correlated with increased time on task, self-confidence, resilience and academic achievement (Dewey, 1910; Erikson, 1969). In this particular case study, emotionality of the project emerged as a consistent theme across most students and the participating classroom teacher. In whole class discussions following Genius Hour students stated that they "felt they were connected to their classmates because the projects helped them know each other better." Many comments from students also reflected on knowing themselves better. In response to the interview question, 'do you think everyone can benefit from Genius Hour?', "Ava" replied "yes, because everyone has a passion" and that the process of Genius Hour "brought out [her] curiosity. "Kay," who created a Claymation of fossilization, felt that the experience was "very engaging" and that it gave her time to work on a topic she was naturally inclined to. The emotionality of the experience is something that stuck with the students throughout the two year study and is evident in "Leon's" narrative:

> When you think back to your project and emotions you were feeling, the process and the final product and what you have produced since then, you realize what you are capable of. It is hard to look at success from the opposite end- once you are past that point and striving for more, it is pretty easy to forget how far you've come, the [interviews] made me think about where I came from instead of where I am going to go next. The project created a lasting impact - it has changed how we look at things- most people did something in that project that influences them today.

The Genius Hour experience was also an emotive experience for the participating classroom teacher. After the culmination of a spontaneous duet between two students,

the classroom teacher remarked the experience "brought tears to his eyes and that it was one of the most moving experiences of [his] career". In the discussion of the projects, he reflected on his career choice and the personal value it had to him. Two years after the project, he remarked that he felt he knew that group of students better than others throughout his thirty year career.

In terms of science identity, quantitative data revealed (Tables 5, 6, 7) that there were marginal gains in students' perception of how much they enjoyed science. This qualitative data was obtained from a comparison of self-report surveys administered before and immediately following Genius Hour. The surveys were administered to the full sample of 136 students. Significance and effect size were calculated for this data. Normalized gains were calculated (Table 6) and results were very similar to mean difference calculations.

Table 5. Descriptive statistics comparison of student Likert ratings prior to and immediately after a Genius Hour Project (n=136)

		Mean	N	Std. Deviation	Std. Error Mean	Effect Size (Cohen's d)
Science is something I enjoy	Pre-GH	61.912	136	21.525	1.846	0.028
	Post-GH	62.500	136	22.262	1.909	
Science is something I am good at	Pre-GH	65.441	136	18.653	1.599	0.192
	Post-GH	61.324	136	19.657	1.686	
I see myself as a scientist	Pre-GH	42.353	136	24.773	2.124	0.145
	Post-GH	39.265	136	22.694	1.946	
Others see me as a scientist	Pre-GH	37.647	136	23.859	2.046	0.076
	Post-GH	36.103	136	21.915	1.879	

Marginal gains were also found in regard to the students' the ability to see themselves as scientists and their perception of how others view their scientific

capabilities. However, these gains were not significant (p=0.093, p=0.377, respectively) (Table 7).

Table 6. Normalized gains comparison of student Likert ratings prior to and immediately after a Genius Hour Project (*n*=136).

	Mean Difference
Science is something I enjoy	0.031
Science is something I am good at	3.504
I see myself as a scientist	2.696
Others see me as a scientist	1.183

Table 7. Paired samples comparison of self-ranking scores for science self-efficacy and identity prior to and immediately following participation in Genius Hour (*n*=136).

				95% Confidence Interval of the Difference				
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper	T	df	Sig.
Science is something I enjoy	.588	21.318	1.828	-3.027	4.204	.322	135	.748
Science is something I am good at	4.118	21.516	1.845	.468	7.766	2.232	135	.027
I see myself as a scientist	3.088	21.310	1.827	-.526	6.702	1.690	135	.093
Others see me as a scientist	1.544	20.326	1.743	-1.903	4.991	.886	135	.377

Effect size was also calculated for these measures. Cohen's *d* standard of 0.2 or lower indicates a small effect size, while 0.3-0.5 indicates a medium effect size and 0.8 or higher indicates a large effect size (Sullivan & Feinn, 2012). As 0.2 is considered a small effect size (Sullivan & Feinn, 2012), the mean change in how students see themselves as scientists was determined to be 0.145, which may be classified as very small (Table 5).

Student ratings regarding a change in science ability was significant and approaching a small effect size and this data will be discussed in the section on self-efficacy.

Despite the absence of significant quantitative results from the survey data, quantitative results from three administrations of exit cards (Appendix E), which asked students to respond to the question 'how does this project make you feel?', indicate a positive influence of Genius Hour. Students indicated overwhelmingly positive feelings (enjoyment, competence, anticipation) during the project as evidenced by 89%-92% of students expressing positive emotions throughout the three administrations (Figure 2). Figure 2 also indicates a trend of increasing competence reported by the students as their projects were developed throughout the weeks.

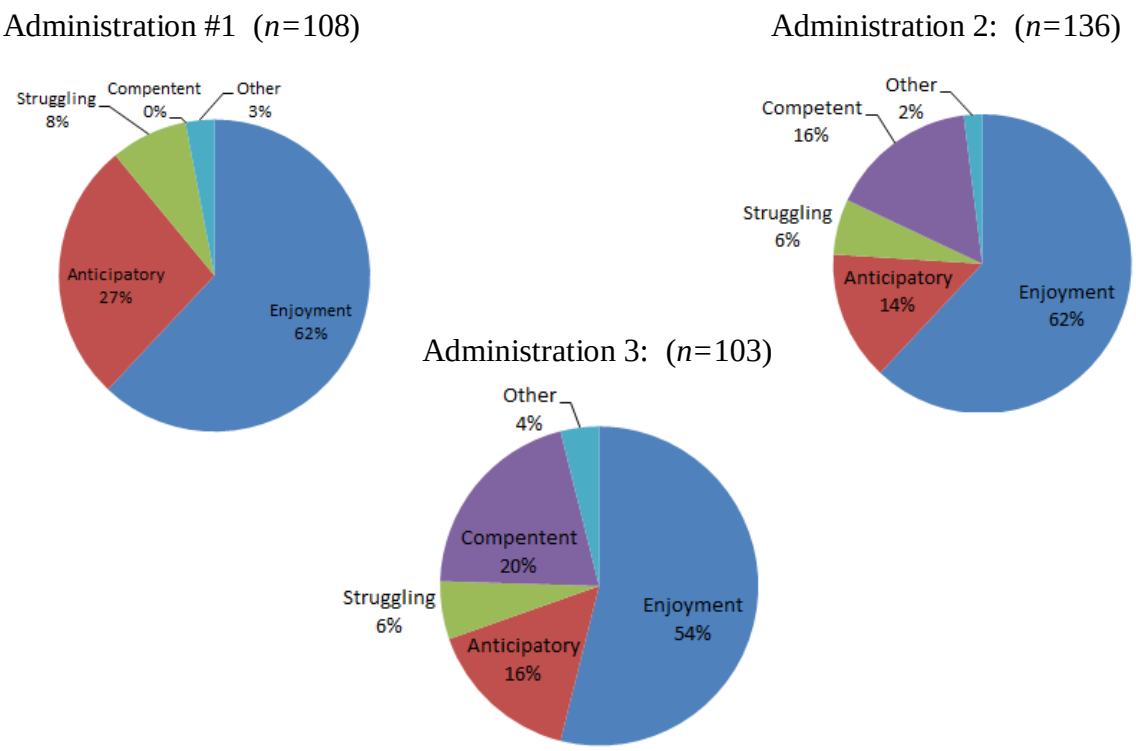


Figure 2. Categorized exit card data expressed as a percent summarizing how students feel about their Genius Hour project obtained at two week intervals throughout the project.

The participating classroom teacher also anecdotally expressed enjoyment throughout the process, particularly during the student presentations where he felt he "really got to know the students" and learn about their passions. When one considers all of the quantitative and qualitative data sources for this theme there appears to be a connection between Genius Hour and positive emotions, despite the presence of non-significant results on the Likert rating scales. The qualitative data provides insight into not only the feelings associated with Genius Hour, but which components of the instructional technique students felt contributed to their enjoyment.

Theme 3: Cultural Acceptance of Uniqueness. One of the key components of Genius Hour is the creation of a project that is shareable to a larger community than exists in the classroom (Kesler, 2014). To address this criterion, students in this study were required to present their findings in the form of a video summarizing their project. At the culmination of the project students shared their videos with the class and commented on their learning process in addition to fielding questions from their peers. Throughout the Genius Hour process there were ongoing student-student, student-teacher, student-family, community interactions; however, the component of Genius Hour most commented on by students in this study was the culminating presentation of their work.

Howard (2000) discusses the importance of symbolic interaction in identity formation, where individuals have meaningful exchanges with others that influence their self perception. "Kay," who studiend fossilization, indicated that she had some trepidation about her project until it was well received by the class, stating "I thought [the project] was kind of dumb and then everyone liked it and that made me feel good about it". The social acceptance by her peers and positive remarks she received anecdottally appeared to validate her identity. In reflecting on the value of the final presentations "Kay" revealed she had "been wearing dinosaur shirts ever since 5th grade and only shared her knowledge with close friends and family" and that no one ever realized her passion until she did her project. She described the experience of Genius Hour as a "self-esteem booster" and the longitudinal look back at her project two years after its completion enabled her to "see the growth" which made her think she is "more than just a

student with a GPA". The theme of social validation was also expressed by "Leon" in the following quote:

> I feel like I needed the validation from peers to know what I had to offer was valuable…. Usually you are in a situation where you are judged for your imperfections, but the imperfections are what make you interesting to someone else- I got to express who I am. Genius Hour lets you pinpoint who you are and what you enjoy, but it isn't just about you- its providing for other people and letting them learn from your experiences.

"Leon's" quote revealed that the process of sharing and receiving feedback on one's passion project was beneficial to both the student and the class as he explored the idea that individual narratives as they may resonate with their peers and community. While much of the available information on Genius Hour available in books, videos, blogs and wikis discuss individualism and personalization as central themes to this educational strategy, this study revealed the social component of sharing one's passions and having them accepted by peers was one of the greatest sources of pride for the students. Social acceptance gave the students the confidence to move from passive recipients of knowledge to active participants and innovators. "Leon" stated the positive feedback he received "helped [him] develop as a person…. Instead of watching others on social media, it let me start to do that…" and that he enjoyed presenting what he felt he had to offer.

The longitudinal study tracked the subsequent activities of students in the sub-sample (n=3-8) and in the course of two years "Leon" began his own YouTube channel (Appendix I) where he experimented with different musical instruments and techniques, which he said continued to boost his confidence and his passion. From the perspective of the researcher, "Leon" took his initial acceptance of his skill during his Genius Hour

presentation and was confident enough to expand his audience, take chances and continue on a path of personal exploration.

Theme 4: Exploration of Interests & Identity. At the introduction of Genius Hour students were asked to reflect on what they were passionate about with the end goal being the selection of a topic for their project (Juliani, 2014). Because the available books on Genius Hour (Juliani, 2014; Krebs & Zvi, 2015; Wettrick, 2014) state the importance of meaningful topic selection, the students in this study were introduced to the concept of Genius Hour and given one week to think of a project idea before our next meeting. Students conferenced with the teacher and the teacher researcher about their topic choice and were asked why each selection was personally meaningful to each student. The responses to these questions were varied. Some students expressed a desire to fit in socially; "Niko" stated "I want to work on my basketball skills because all my friends are good at basketball". Other students saw an emergent need, "Analise" revealed that she had just adopted a new dog and expressed a desire to learn how to train it. While other students saw Genius Hour as an opportunity to expand existing passions. "Kay" shared that she was always passionate about dinosaurs and seized every opportunity she could to research them.

At the culmination of Genius Hour, some students revealed that the Genius Hour allowed them to explore their interests and learn about themselves. "Ava" reflected that Genius Hour "brought some things out I didn't know were there before- I didn't know I had all this dedication for technology and Genius Hour helped me discover it". Other students reflected on the project more objectively and compared it to other classroom

experiences that they had. "Kay," who created a Claymation of fossilization, stated she "loved the freedom to pick anything…. and thought it was really nice [she could] share it with the class any way [she] wanted". This comment was mirrored by another student in an individual interview that said she enjoyed Genius Hour because it gave her the freedom to "do anything that described you as a person or influenced your life beforehand". This same student drew connections between identity and self-efficacy said that such personalization "made [the project] fun to do- [she] didn't have to talk [herself] into doing it- it came more naturally". As indicated in Chapter Two, Dewey's Interest Theory (1910) states that the more enjoyable a task is, the longer students will persist in working on the task and additionally they will demonstrate greater resiliency than tasks for which there is no personal investment.

Throughout this study, students consistently expressed positive regard for the radical autonomy that Genius Hour allowed them. In class discussions, many students expressed that the radical autonomy component of Genius Hour was initially challenging because the project was ambiguous until they themselves defined it, but indicated it was perhaps the most salient feature that separated Genius Hour from other project based tasks. "Guy" said "…it was so hard to pick a topic and do whatever I want because I'm not used to that, but in the end it was the best part". Radical autonomy and its perceived positive effects on identity in the context of this study may contribute to increased student engagement and enjoyment as they perceive their task as meaningful.

Theme 5: Integration of Science into Personal Identity. The application of Genius Hour in this study took the form of students examining any topic of their choice through a

scientific lens. In essence the challenge posed to the students of creating a project based on "the science of [their personal passion]. As indicated in Chapter Two, the Hybrid Identities Theory states that personal interests may be merged with academic knowledge if school programming challenges students to bring their personal interests and values to the classroom (Guiterrez, 2008).

A noteworthy event occurred during the presentations of the Genius Hour projects. "Leon," who studied the science of the guitar and "Alex" sang an impromptu of Monsters and Men song to their peers. This event appeared to be a manifestation of Hybrid Identities (Guiterrez, 2008) as these students created a presentation that reflected a merger of their personal interest of music and science. In reflecting on his experience, "Leon" stated he felt "on top of the world" and that the experience "changed how [he] saw this class and science" and that he had "not previously saw himself as a scientist". He went on to say that his established passion for music "initially led him to consider teaching music and science was something [he] hadn't previously considered". This initial revelation evolved for "Leon" over the course of the two year study, where as a high school senior he is planning on pursuing post-secondary studies in engineering and hopes to engineer musical instruments as a future career. The following quote emerged two years after the culmination of Genius Hour.

> As the years went by I was starting to think about college and music is where my passion is… I've enjoyed it and at the same time I enjoy drawing and computer work. I realized I could morph the two together… with mechanical engineering, I could design guitars, or smaller things like tuning devices, [Genius Hour] broadened what I could do and changed my path to engineering….

A parallel phenomenon occurred for “Ava,” who was also part of the longitudinal study. “Ava” expressed future career aspirations to become a snow scientist where she could combine her love of skiing with science. She described her project as a “broadening experience” and caused her to consider an alternate career path working for the Parks Service she had not thought of before. The experiences of both “Leon” and “Ava” may be exemplars of theory developed by Guiterrez (2008) in his discussion of Hybrid Identities Theory where the successful facilitation of the ‘third space’ can lead to a new identity. The qualitative quotes from this study provide insight into the personal narratives of the students as the experienced the merger between their historical narratives about their future careers and the emergent narratives resulting from participating in Genius Hour.

For some students, the experience of Genius Hour challenged them to reconceptualise what it meant to be a scientist and to put this new definition within reach of their own capabilities. “Alisha,” who studied the science of learning music, said that she “realized not all science is super complicated or hard to understand and science is everywhere in everyday life” and that she realized she had “already been doing science accidentally” which made her “more confident” in her abilities. “Dennis,” who studied the science of scary movies, stated that he thought “everyone is a scientist in the sense that they can look at something and be curious about it and research it” when reflecting on his unconventional project that tried to examine the components of scary movies that people had the greatest emotional response to. A similar response by “Maryanne”, who studied the science of running, reflected that she sees herself as a scientist “in certain

ways, maybe not as a textbook definition", but felt that having "an interest to want to learn more could qualify [her] as a scientist". The reconceptualization of 'scientist' by students participating in Genius Hour seemed to make this role more inclusive than it was before creating their projects.

The quantitative results of this case study saw a marginal gain of 3.5% in students' rating to the prompt "I see myself as a scientist (Tables 5, 6, 7). However, the results were not statistically significant. It is important to note that while significant statistical claims cannot be made, there is a an ample body of qualitative evidence that suggests that Genius Hour not only challenged students' initial conceptions of what it means to be a scientist, but also their beliefs about themselves as scientists. All respondents that participated in individual small group interviews ($n=8$) expressed an alteration of their working definition of a scientist and expressed that at the culmination of the study they saw, at the very least, components of their personalities that aligned with their conception of a 'scientist'.

Self-Efficacy Themes

Self-efficacy is defined as a belief in one's ability to succeed in specific situations to accomplish a task (Halloun, 1998). Recent research in self-efficacy has examined the influence of both resiliency and external influences such as praising effort in increasing self-efficacy (Oliver & Venville, 2011). This study examined the influence of Genius Hour on self-efficacy broadly and also examined discipline-specific science self-efficacy. Both quantitative and qualitative data were analyzed for this section.

Science Self-Efficacy is the belief in oneself to do science competently (Aschbacher, 2009). The critical word in that definition is the word 'do' implying science is a verb, rather than solely a body of knowledge. This idea is supported by the National Research Council (2016) in the development of Science and Engineering Practices which are a set of scientific behaviors students should develop throughout their lifetime. The broadness of the practices enables them to be transferrable to many different contexts and such behaviors form the basis of inquiry learning which is an approach that is often more authentic, therefore more valuable in real-world situations (Llewellyn, 2007). This study indicated that students experienced a cycle of problem solving in working through their own passion project and that the motivation for this was influenced by instrinsic factors, namely the desire to explore curiosity in something they were already interested in and extrinsic factors, such as the interaction with the learning community, which appears to be congruent with the findings of the study as well as current motivational research (Kantier, 2009).

Theme 6: Effort, Time & Immersion. The majority of students in this study stated that Genius Hour did not feel like work because they were working at something in which they were already interested in. Having authentic interest in a task increases the amount of time a student will spend on a task as well as their level of persistence when they encounter setbacks (Dewey, 1910). Enjoyability and passion for a task are components of Genius Hour that other research suggests promote resiliency (Maiers & Sanvold, 2014). "Cole", who studied the science of unicycling, indicated that Genius Hour "was something [he] liked so [he] put more work in to it". In whole class

discussions students revealed that they "prioritized Genius Hour because it was fun" , "put more effort in because it was successful" and spent "more time on Genius Hour than any other project". In terms of time management, students felt that working on Genius Hour as compared to other traditional task was easier because you "could squeeze into your everyday life because you already enjoyed it". In this statement, Hybrid Identities Theory (Guiterrez, 2008) may also extend to the area of self-efficacy in that personal interests likely already have a time and place in which they are occurring so when students are applying academic knowledge in this dedicated time and space, they don't need to alter their routines significantly. Recall from Chapter Two that mastery is a component of Genius Hour and is also an established motivational factor (Pink, 2011). For mastery of any skill to occur, as significant amount of time must be spent developing it (Brophy, 2004). By assimilating academic knowledge with personal interests, more time can be devoted to skill development. In essence the 'third space' described by Guiterrez (2008) occurs at both school and at home. Many students shared that their family provided input into their projects, suggesting the academic realm of school had infiltrated the home environment during Genius Hour. Quantitative data from the exit cards completed by students at three intervals during the project indicated a trend of growing competence as the project progressed (Figure 2) and this may be due to increased mastery from the time devoted to the project. Additionally, research has established a connection between the amount of effort spent on a task and the level of personal investment (Anderson, 1988). This may account for the saliency of the Genius Hour project where students remembered the intricate details of their projects and the

feelings they had at least two years after its culmination. "Cole," who studied the science of unicycling, indicated that "perseverance was key, because you had to dedicate all this time to the project." Students indicated that they "felt the project was meaningful because it revealed what [they] are capable of doing" and in longitudinal interviews, they saw their success in Genius Hour as a major stepping stone to future endeavours. "Ava" reflected that her "work ethic increased because [she] had to do more work outside the classroom" and that the project helped her develop organizational skills and time management. In the subsequent years following her own Genius Hour experience, her younger brother participated in Genius Hour and she shared that his project on elk migration permanently changed his mindset evidenced by his discussion of his project every time he saw a fence while the family was driving through National Parks. When one considers a fence can trigger previous academic learning, it seems mastery of the skills associated with his project would seem very likely. This phenomenon was also observed in the participants of this study where "Kay" shared that after Genius Hour more of her "friends know [her] passion for Genius Hour and ask me questions and ask me to draw dinosaurs for them". In this instance it appears that Genius Hour is the starting point for numerous interactions and conversations which may also lead to mastery learning.

In the domain of science, research suggests many students struggle to access known scientific principles to personal problems and dilemmas (Anderson, 1988) and education reformists believe that is is because science is traditionally taught as a body of facts rather than ways of thinking (Robinson, 2007). In this study, qualitative comments

indicated students felt more confident in their scientific abilities stating such observations as “I can now see science everywhere and I am willing to try things I wouldn’t have tried before”. Quantitative data obtained in this study (Tables 5, 6, 7) lends support to these comments as students experienced a statistically significant change in their self –rating of the statement ‘science is something I am good at’. A paired samples t-test (n=136) was conducted to compare students’ evaluation of their science competency before and after Genius Hour. There was a mean difference of +4.120% that was statistically significant (p=0.027) with an effect size approaching small (0.192). A normalized gains calculation was also performed and indicated a mean difference of +3.500%. These results are important because they show that after participating in Genius Hour, students identified that they were more competent in their scientific abilities.

In the context of this study, qualitative comments suggest that Genius Hour was a considerable undertaking for the students that required substantial time and effort, while quantitative results revealed a small increase in students’ appraisals of their scientific abilities. Time, effort and the immersion of students in their Genius Hour projects that results from the blending of home and school environments as their personal passions are assimilated with academic knowledge appeared to contribute positively to the students’ self-efficacy.

Theme 7: Cultural Acceptance of Effort. Categorized exit card data expressed as a percent summarizing how students feel about their Genius Hour project obtained at two week intervals throughout the project. Categorized exit card data expressed as a percent summarizing how students feel about their Genius Hour project obtained at two week

intervals throughout the project. As discussed previously, the presentation of students' Genius Hour projects was a salient experience for most students. In addition to students feeling that their individuality and uniqueness was accepted and celebrated during this time, qualitative comments revealed that the acknowledgement of their effort also occurred. "Kay," who created a Claymation of fossilization, stated that she had the opportunity to "negotiate the assignment and be more creative" and that her project let her "express herself". She also reflected on the amount of positive feedback she received for her drawings and sculptures where "other students noticed how much time [she] put in". Additionally she indicated positive feedback for her Claymation came from the larger community as her friends and family asked her to post her video on social media, where she joked "my family is obsessed with it". "Ava" reflected that she was "a much more driven person afterwards" because of the encouragement she received about her work ethic throughout the project. Current research suggests that praising processes and effort rather than final products as well as stimulating metacognitive reflection regarding the behaviors that created a project can greatly increase self-efficacy (Aschbacher, 2009).

The sub-sample group (n=3-8) from the longitudinal component of the study, revealed that a great source of pride that came from Genius Hour was the result of "having something to show for." "Ava" said that she thought "everyone benefitted from Genius Hour and continues to benefit to this day" citing an example of her classmate who used scientific conditioning principles to train her new dog. "Ava," who continues to interact with the Genius Hour dog belonging to her friend "Amy", reported it was still perfectly trained and a source of pride for its owner. Students also indicated that in their

activities following Genius Hour, they continued to receive more positive feedback from others. "Leon," who studied the science of the guitar, believed that Genius Hour was a "stepping stone that put [him] in the direction for continuous improvement" and that "there were some shining moments" where the "influence of Genius Hour magnified over time". When "Ava" watched her avalanche video again, two years after its initial creation, she noted "we have come so far and changed a lot in that time period… I forgot what I was capable of" and recalled fondly the encouragement and validation she received from her friends and family. All students in the longitudinal study indicated Genius Hour helped them realize their ability to put substantial time into a task. When one considers sustained effort usually leads to actual ability and an established relationship exists between real competence and self-efficacy (Brophy, 2004), it is possible that the culture of Genius Hour where significant time and effort is devoted to a task would contribute to self-efficacy in students.

Theme 8: Resilience and Self-Reliance. Findings from this research also indicate that Genius Hour allowed for 'failure' in the sense that it is process, rather than the product, that is most important (Juliani, 2014). During Genius Hour instruction, teachers often act as 'guides on the side' rather than orchestrating learning for the students. Students come into their Genius Hour project with some existing knowledge because their project is based on something they are passionate about, however, because each individual student has a unique project, students must solve many setbacks themselves. One common reluctance of teachers to implement Genius Hour is that they fear they cannot be content masters of everything the students could possibly be interested in.

Juliani (2014) and Wettrick (2014) suggest that this perceived inadequacy is okay and that it may even develop greater self-reliance and resilience in students because is no source of 'easy answers'.

"Ava" indicated that with limited help from teachers and family she "had to flex [her] muscles a bit more, which was very rewarding". Many students revealed vignettes that revealed resiliency and self-reliance, factors contributing to self-efficacy (McLean, 2015); "Louise," who studied memory, shared that she had to do three different video recordings, while "Cole," the unicycler, had a few improvements he would still make to his project, despite it being very well received by his teacher and his peers.

In regards to the discipline of science, a student stated the openness of the assignment compared to "traditional science classrooms that are very strict and organized, allowed me to branch out and decide things for myself". "Leon" said that he "enjoyed figuring out things through experimentation". He went on to describe a reconceptualization of science as discipline as a result of participating in Genius Hour:

> Genius Hour changed my view of science – instead of doing experiments that other people have already done- you get the opportunity to look beyond the horizons of what has been done- this is the true nature of science.

The nature of science described by "Leon" is one that is well supported (UC Berkeley, 2015). UC Berkeley (2015) emphasizes that science is not a sequence of linear steps, but can be messy and complex and more holistic than is often represented in science classrooms. Research suggests that simplistic, linear models can erode student science self-efficacy when they encounter a problem that is not easily solvable and requires sustained effort (Aschbacher, 2009). The shift towards science as ways of doing

and as ways of thinking presented in the Science and Engineering Practices (National Research Council, 2016), may help increase resiliency and self-efficacy because each practice exists as a continuum of expertise rather than a discrete end point. In the context of this study students were asked to perform self-ratings on their perceived competencies for each of the Science and Engineering Practices (Oliver & Venville, 2011) prior to the start of Genius Hour and at its immediate completion. While it is important to note, the students in this case study had limited experience with the Practices, the language used to describe each one is straightforward and easily interpretable by most students.

Of the eight Science and Engineering Practices, results from this study revealed statistically significant results (p=0.05) for the Practices of "asking questions and defining problems" (Mean Difference 3.68, p=0.016) and for "analyzing and interpreting data" (Mean Difference 4.36, p=0.036) (Tables 8, 9). The effect size for both "asking questions and defining problems" and "analyzing and interpreting data", were small to very small, 0.210 and 0.154, respectively (Table 8).

Table 8. Descriptive statistics of self-ranking scores for NGSS Science and Engineering Practices prior to and following participation in Genius Hour, *n*=136

		Mean	N	Std. Deviation	Std. Error Mean	Effect Size
Asking questions and defining problems	Post-GH	71.397	136	18.466	1.583	0.210
	Pre-GH	67.721	136	19.999	1.714	
Developing and using models	Post-GH	70.901	136	20.174	1.729	0.004
	Pre-GH	70.809	136	17.891	1.534	
Analyzing and interpreting data	Post-GH	72.813	136	20.581	1.764	0.154
	Pre-GH	68.456	136	22.571	1.935	
Planning and carrying out investigations	Post-GH	71.864	136	20.394	1.748	0.082
	Pre-GH	73.677	136	18.927	1.622	
Using mathematics and computational thinking	Post-GH	73.268	136	20.930	1.794	0.039
	Pre-GH	72.427	136	21.722	1.862	
Constructing explanations and designing solutions	Post-GH	71.636	136	19.756	1.694	0.078
	Pre-GH	69.853	136	18.658	1.599	
Engaging in an argument from evidence	Post-GH	73.897	136	20.590	1.765	0.141
	Pre-GH	70.588	136	22.036	1.889	
Obtaining, evaluating and communicating info.	Post-GH	73.996	136	18.328	1.571	0.100
	Pre-GH	71.001	136	18.532	1.589	

Table 9. Paired samples t-test comparison of self-ranking scores for NGSS Science and Engineering Practices prior to and following participation in Genius Hour, *n=136*

				95% Confidence Interval of the Difference				
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper	T	df	Sig.
Asking questions and defining problems	3.676	17.546	1.505	.701	6.652	2.444	135	.016
Developing and using models	.092	21.135	1.812	-3.492	3.676	.051	135	.960
Analyzing and interpreting data	4.357	24.025	2.060	.282	8.431	2.115	135	.036
Planning and carrying out investigations	-.489	24.673	2.116	-4.673	3.695	-.231	135	.818
Using mathematics and computational thinking	.841	21.673	1.858	-2.834	4.517	.453	135	.651
Constructing explanations and designing solutions	1.783	22.864	1.961	-2.094	5.661	.909	135	.365
Engaging in an argument from evidence	3.309	23.414	2.008	-.662	7.280	1.648	135	.102
Obtaining, evaluating and communicating info.	2.011	20.111	1.725	-1.400	5.422	1.166	135	.246

Normalized gains calculations revealed that the amount student ratings increased for each of the Science and Engineering Practices after the completion of Genius Hour was slightly smaller (Table 10). However, the normalized gains calculations (Table 10) and the mean differences presented in Table 9 were similar enough that they mutually support each other. If there were large differences between the mean differences and normalized gains, other factors may have influenced the results, such as major decreases in students' perceptions of competence on the Science and Engineering Practices (Hake, 1998).

Table 10. Normalized gains of mean differences in students' self-ranking scores for NGSS Science and Engineering Practices prior to and following participation in Genius Hour, n=136

Asking questions and defining problems	2.999
Developing and using models	-0.616
Analyzing and interpreting data	3.672
Planning and carrying out investigations	-1.213
Using mathematics and computational thinking	0.118
Constructing explanations and designing solutions	1.085
Engaging in an argument from evidence	2.603
Obtaining, evaluating and communicating info.	1.291

Although the gains seen with Genius Hour on the Science and Engineering Practices of "asking questions and defining problems" and "analyzing and interpreting data" were significant, but quantitatively marginal with small effect sizes, the information is valuable in comparing the development of these skills in relation to each other. A Genius Hour project that lasts the entire year may yield the same patterns with greater normalized gains scores and would be an excellent area of future research.

Conclusion

Based on the numerous quantitative and qualitative sources of data in this study, claims can be made that Genius Hour does influence students' identity and self-efficacy as well as their science identity and self-efficacy in mainly positive ways. The longitudinal component of this study provides insight into the most salient components of Genius Hour and the long lasting influence in the students' lives and serves to increase the validity of the claims. It is important to reiterate that self-efficacy and identity do not exist as two separate conceptual entities, as evidenced by many student quotations being

able to provide evidence for multiple themes generated in this discussion. The implications of these findings will be discussed in Chapter Five.

FINDINGS, CONCLUSIONS AND IMPLICATIONS

Introduction

The purpose of this mixed methods study was to better understand the influence of Genius Hour on student identity and self-efficacy with more detailed examination of science identity and science self-efficacy for high school science students. Results of this study operationalized Genius Hour, evidenced the mechanisms at work during the Genius Hour process and suggested ways in which students were changed as a result of their creation of a Genius Hour project. A sub-sample of students was followed for two years after their Genius Hour experience to ascertain any lasting impacts and/or novel reflections gained from having subsequent educational experiences. The major research question for this study was: How does participation in Genius Hour influence identity and self-efficacy in high school science students? The following sub-questions, pertaining specifically to the discipline of science, were also used to structure the investigation: How does Genius Hour develop science identity? How does Genius Hour develop science self-efficacy?

It is important to note that identity and self-efficacy were studied broadly and then specifically within the domain of science. Epistemologically, students possess both domain general and domain specific knowledge and skills, and while historically transferability between these two realms of knowledge was assumed, new research suggests this is not always the case (Anderson, 1988). Therefore, it was critically

important to determine the broader influence of Genius Hour and its influence in the science domain.

The following chapter presents a summary of the research design, with findings organized into identity and self-efficacy headings. The findings will be discussed globally and then specifically as they pertain to the domain of science. Emergent themes will be explored and implications for practice will be reviewed. As this study is a pioneering venture, there is considerable discussion regarding recommendations for future research at the end of this section.

Limitations of Study

One key limitation of this study was the relative lack of peer-reviewed research on Genius Hour, and the development of an empirically driven definition of the technique from which to build a previously vetted research design. Due to the complexity of Genius Hour, it is a phenomenon that could be examined through many different theoretical lenses, such as, but not limited to motivation theory, social learning theory, identity theory, social constructivism, cognitive constructivism, metacognition/ mindfulness, understanding by design and passion-driven learning. For the purposes of this study, the researcher selected frameworks with the strongest alignment to Genius Hour and identity and self-efficacy research, namely Hybrid Identities Theory (Gutierrez, 2008) and Interest Theory (Dewey, 1910). Some of these alternative frameworks are discussed in subsequent sections of Chapter Five where further research recommendations for Genius Hour are made.

The major limitation of this study was that it was context bound to one high school in the Rocky Mountains with one participating classroom teacher. However, 136 students participated in the study with a sub-sample group providing data for two years after the culmination of Genius Hour. The sub-sample group experienced attrition with the original group consisting of eight students, with three students present for all data collection intervals. The longitudinal component attempted to provide depth of insight into the influence of Genius Hour on identity and self-efficacy and specifically on science identity and self-efficacy. To help address issues of generalizability, interview responses were sought from all participants and the sub-sample was often asked to reflect on their peers' Genius Hour experiences. The responses and generalizations made by the researcher were confirmed fair and accurate by the research participants to increase validity. Additionally, triangulation was achieved through using different interview scenarios, written responses, and quantitative ranking scales. Pre and post Genius Hour ratings for questions related to identity, self-efficacy and the Science and Engineering Practices were compared using paired t-tests and normalized gains. A limitation of normalized gain measures is that there is the assumption of a gain and losses are not indicated in the calculation (Hake, 1998). However, Hake (1998) notes the major advantage of using normalized gain it that initial differences in a diverse population are accounted for. In the classroom, normalized gain calculations level the playing field for all students by presenting increases in numeric data, proportionally to the total gain that is possible when initial performance is taken into account.

Despite the challenges and limitations of this study, the data and conclusions presented are valuable as initial conceptions regarding a previously unstudied phenomenon. Additionally, the findings of this study provided new insights and confirmed existing findings about identity and self-efficacy. Identity research, specifically in the sciences, may be a way to cultivate more post-secondary STEM students to meet the demands of the North American workforce (Aschbacher, 2009).

Implications

As indicated in Chapter Four, findings suggest possible relationship alignment between the three pillars of Genius Hour, namely autonomy, mastery and purpose and how they support self-efficacy and identity was described in Figure 3. An example was described where a student chose to develop her skill of knitting because of fond memories with her grandmother and spent a considerable amount of time developing her skills because of her personal motivations. Her personal sense of pride in her new skill, combined with validation from others shifted knitting from an activity that she could do into part of her identity where she declared "I am a knitter". While this shift may seem subtle, it has considerable ramifications for education. Identity can be defined as the sum of a person's actions and beliefs they hold about themselves (Faircloth, 2012). And that identity is developed through a process of exploration, where one may try on new identities, alter an existing one, incorporate or reject different parts of oneself in response to interactions with the environment (Lee, 2007). Such dynamic processes suggest that identity is a malleable construct; therefore, it may be a variable in learning that can be

influenced in the classroom. Additionally, identity formation can be influenced by self-efficacy as individuals are most likely to develop the components of themselves they feel they have an aptitude for (Blumenfield, 1991). Lee (2007) and Guiterrez (2008) suggests teachers can encourage identity exploration in students by the construction of the 'third space,' a time and place where students' personal interests and passions can interact with traditional academic knowledge (Guiterrez, 2008). In this interaction students see not only the real world applicability of academic knowledge; they may also see the value in their 'street smarts' (Lee, 2007) which may increase their self-efficacy. As evidenced in the knitting example, it may be the shift from knitting as an activity to 'being a knitter' is the result of the value assigned to the concept of knitting. 'Being a knitter' is much more personal and close to the heart than merely performing the activity of knitting as a sense of ownership is implied in the statement. If teachers can facilitate this value shift, it may translate to significant gains in content knowledge and skills, as individuals will be motivated to take pride in their learning if it is a component of their identity.

In terms of science education, research suggests identity development may help to address the critical need for students in the STEM fields (Aschbacher, 2009). If students see themselves as scientists, they may be more likely to pursue the mastery of skills and this increased confidence and competence and self-efficacy would likely reinforce their identity as scientists because research suggests individuals are most likely to incorporate skills they excel at into their identity (Anderson, 1988). One important clarification to make is that it should not be the goal of science teachers to turn all students into scientists. As with every domain of knowledge, there will be certain students who have a

greater proclivity for science than others. However, as suggested by Lee (2007), a classroom teacher can facilitate identity exploration, providing students opportunities to try on different identities. Such an exploration may not lead to the incorporation of science into a student's identity, but may increase the value of science for students. In this study "Suzi" proclaimed loudly that she was not a scientist and "did not want anything to do with science-yuck!", but at the end of her Genius Hour project on trying to discover the best chocolate chip cookie recipe, she saw the value of science skills in helping her develop her identity as a baker. Science, as a discipline, provides students an understanding of the natural world and therefore, it exists as a body of skills and knowledge that is at least partially applicable to every student, regardless of whether or not they fully embrace a scientific identity. The construction of the NGSS, particularly the Science and Engineering Practices (National Research Council, 2016), which frames science as broad ways of thinking (asking and defining problems, communicating ideas etc.), promotes application of science to a diversity of contexts and therefore capable of further developing the personal identity of any student regardless of whether they are a baker, an artist or construction worker.

A considerable gap in the research exists in regard to Genius Hour's influence on identity and self-efficacy. However, based on this study's findings, a strong case can be made that Genius Hour is a possible mechanism to support the development of identity and self-efficacy in the classroom. The results of this study have shown the merger of school and home in the 'third space' facilitated by Genius Hour contributes to increased student engagement, self-knowledge, self-efficacy and identity formation. The following

sections will explore the emergent themes in this study in greater detail and suggest possible avenues for future research.

Review of Emergent Themes & Discussion

Operationalization of Genius Hour

The three motivational pillars of Genius Hour described by Pink (2011) are autonomy, mastery and purpose. In the review of existing Genius Hour publications, the researcher was cognizant of these components, and it was clear that they were present to varying degrees in practitioner accounts (Krebs & Kirr, 2014). From the review, teachers had the most fidelity to 'purpose', with 'mastery' and 'autonomy' showing much greater variability between teachers and different classroom contexts. The degree of fidelity to each of the pillars of Genius Hour in teaching practice is important information because it allows us to see which component has the greatest influence on identity and self-efficacy. Furthermore, if a goal of instruction is to develop identity and self-efficacy in the classroom, it is important for teachers to know which areas of the instructional technique may be customized without compromising such goals.

Purpose, as experienced in Genius Hour, takes the form of students self-reflecting on the things and activities that are personally meaningful to them as they choose a topic of study. This particular pillar of Genius Hour may have the greatest influence on identity because research suggests identity is often emotive and values-based (Lee, 2007). *Purpose* is one of the components of Genius Hour that separates it from other project-based learning tasks as other project-based learning tasks (Kesler, 2014), projects which

are often chosen by teachers, reflecting their values rather than the students'. Qualitative comments in this study overwhelmingly stated that students enjoyed the personalization of the project and saw this as a feature of Genius Hour that made it different than other school tasks. Allowing students to express their purpose may have accounted for the strong momentum in continued learning the students in the longitudinal study expressed after the culmination of the project.

Autonomy manifests itself in Genius Hour as students having the ability to choose a topic of study, an approach, a method of communication and in some cases, the indicators of quality (Juliani, 2014). As indicated, identity is oftentimes defined as a collection of choices individuals make in certain contexts (Brophy, 2004). Therefore, it follows that tasks which require more decision making are more strongly activating individual's identity. Students in this study repeatedly stated that the extreme freedom of the Genius Hour project was an aspect that they found initially challenging, however, they stated it provided the most enjoyment in their discussions at the end of the project. Furthermore, they stated that the accolades they received following their presentation were more salient because the project was theirs and "reflected [their] values and who [they] are", "Leon," who performed a song with a peer in class as part of his presentation on the science of the guitar.

Mastery is an important component of both self-efficacy and identity. When students are given multiple opportunities to practice skills, these skills show improvement (Marzano, 2004) and greater actual competency and achievement can lead to increased self-efficacy (Anderson, 1988). Anderson (1988) also describes a positive feedback loop

where achievement leads to self-efficacy and greater self-efficacy leads to greater achievement. In terms of identity, research suggests the greater the amount of time spent in the 'third space', the junction where personal knowledge and academic knowledge meet, the greater the identity development that occurs (Lee, 2007). If an aim of science education is to increase the number of students in STEM fields, it would follow that more time students would spend in the 'third space' (Gutierrez, 2008), the more likely they would be to see themselves as scientists. Further, self-efficacy and identity are inherently linked where individuals are most likely to create identities based on their perceived skills and attributes (Lee, 2007). Therefore, it follows that the length of time of a Genius Hour project may be a major determining variable in student identity and self-efficacy development.

The following schema was developed following data analysis and suggests a possible positive feedback relationship between the pillars of Genius Hour and identity and self-efficacy developed from the results of this study. This schema depicts how Genius Hour may support identity and self-efficacy development and suggests a possible positive feedback relationship between the two constructs. During project selection, students participating in Genius Hour must activate their passions, prior experiences and demonstrate self-understanding (Juliani, 2014). If the student selects a project that is authentically meaningful to them, Dewey's (1910) Interest Theory suggests that they will spend a greater amount of time on task due to intrinsic motivation. Increased time on task is likely to increase both skills and subsequently, self-confidence (Marzano, 2004).

Self-confidence in an area can lead to greater resiliency and self-efficacy (Buck Institute for Education , 2015).

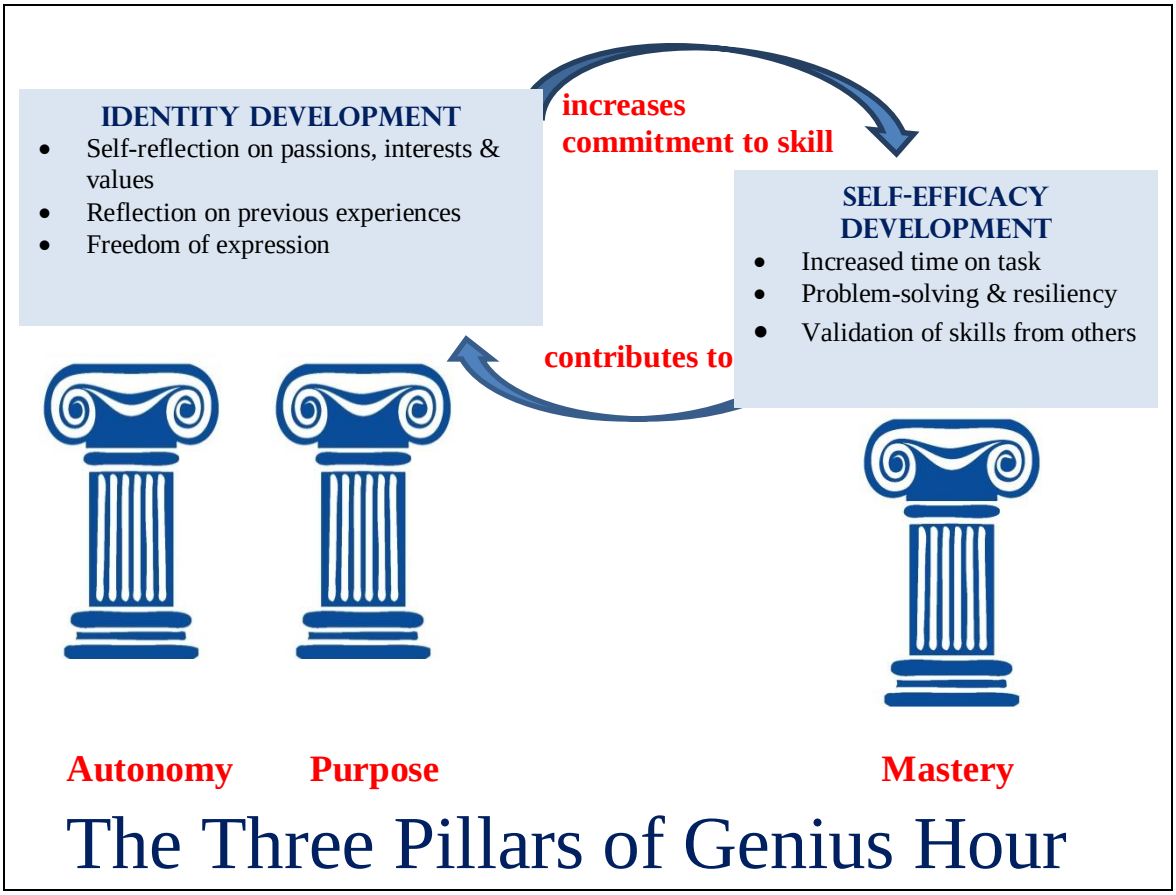


Figure 3. Proposed relationship depicting how Genius Hour may develop identity and self-efficacy.

Once a student feels competent and confident in himself/ herself and receives validation and confirmation of these skills by others, they are more likely to incorporate these skill sets into their identity (Erikson, 1969). For example, a student may have fond memories of her grandmother knitting and select knitting as a Genius Hour project. This student may be more devoted to this task than other tasks and as a result, spend longer in mastery, because it is personally meaningful and this time investment will likely lead to

increased knitting skills. Once the student gains confidence in knitting, meets their own expectations and receives validation from others, knitting may shift from an activity to a component of her personality. In essence, she moves from 'doing knitting' to 'being a knitter'.

The implications of this shift may seem subtle at first, but are profound when one considers our personal narratives and self-constructed identity is expressed in every decision that we make and behavior we express (Faircloth, 2012). This implication may account for trends in this study where students were influenced by their Genius Hour project two years after the culmination of the project. One may further theorize that any form of learning that is integrated into identity may experience a 'multiplier effect' as students make subsequent decisions and take subsequent actions based on their identity. If the proposed 'multiplier effect' occurs during Genius Hour, this may help alleviate teacher and administrator concerns about the time cost of Genius Hour as the initial time investment may provide increased learning returns versus other methodologies.

The following sections describe the implications of the emergent themes from this longitudinal study. These themes were derived from cross comparisons of qualitative data found in student interviews, class discussions, small group interviews and exit card comments. Quantitative data from survey results and exit cards were also used in the cross comparison.

Identity Themes

Theme 1: Self -Reflection Opportunities. Identity formation is a form of constructive meaning-making that requires self-knowledge and self-reflection (Dewey, 1910). The new potential identity components developed by Genius Hour needed to be accepted, rejected or ignored by the students. Lee (2007) proposed the idea of tentative identities in the classroom where the teacher acts as facilitator to let students experiment with alternate versions of themselves. Tentative identities tend to be solidified and incorporated when they serve the student in some way, such as greater peer acceptance or greater self-confidence (Lee, 2007). Genius Hour can be thought of as a series of value judgements; students must select a project that is personally meaningful and develop their own measures of success based on what indicators of quality are important to them.

Genius Hour challenged students to connect with their inner passions and established components of their identity to choose a topic of study for their project. In adolescence, students work towards answering the fundamental question of 'who am I?' (Erikson, 1969) They refine, reject, accept and change different parts of their identity in response to their experiences and the reaction of others (Howard, 2000). The qualitative comments from the students revealed an overwhelming positive response to the 'radical autonomy' and 'purpose' pillars of Genius Hour, as evidenced by consistent positive regard for the level of choice in the project. Students in this study felt that the radical autonomy of Genius Hour and the ability to pursue their passions were the features that separated Genius Hour from other forms of project-based learning. As mentioned in previous discussion, there were a small number of high achieving students who felt

uncomfortable defining their project for themselves and desired a much greater degree of teacher control. However, these students learned through their reflections that they feel best working in environments with a lot of structure, which is valuable knowledge in itself.

Self-reflection also took place throughout the project, at times guided by the teacher and teacher-researcher and at others, by the students themselves. On the exit cards (Figure 2), which were completed on alternating weeks, students were asked consistently about their feelings in response to their project. Feelings shifted from anticipatory feelings at the beginning of the project to feelings of competence as the project progressed. The percentage of students that expressed negative feelings towards the project such as 'worried', 'tense', 'overwhelmed', 'bored' remained consistent (6%) across time intervals despite interventions by the teacher and teacher-researcher to address the concerns brought forth. It appeared that for a very small fraction of students, Genius Hour was an 'uncomfortable experience.' When these students were interviewed at the culmination of their project, many demonstrated evidence of greater self-awareness. This was demonstrated in their desire to do another project, statements about what supports they would put in place in the future to succeed at the task and additional brainstorming on what topic they wished they had done. "Kay" indicated at the culmination of her project that she "wished [she] had more frames depicting the sedimentation process of fossilization" in her Claymation, while "Cole" indicated he wished he had taken some video from different angles to better demonstrate how a unicycle works. The 6% of students that expressed negative feelings towards Genius

Hour in this study does not suggest that these students are 'unreachable' with this educational technique (Figure 2). Recall that the entire sample (n=136) had no previous experience with Genius Hour and it is a fair statement to say that perhaps some of the 6% would thrive in a subsequent Genius Hour experience. It also may be true that the students made most uncomfortable during the process of Genius Hour have the greatest potential for growth.

The extreme personalization of this project increased its level of engagement, and many students saw their work as an extension of themselves. Returning back the initial writings on motivation by Daniel Pink (2011), such autonomy is strongly correlated with self-satisfaction and motivation. "Leon's" quote can also be connected to identity research as the standards one holds and the indicators of quality of one's work are components of identity (Kaplan & Flum, 2012). Therefore, one may postulate that the self-reflection opportunities at the beginning of Genius Hour may activate established components of identity and throughout the process of Genius Hour these components may be altered through the conversations each student has with himself/herself about their project. Anecdotally, both the classroom teacher and the teacher researcher felt that many of the projects were the absolute best work the students were capable of doing. This observation was confirmed by the students when expressing their pride after their presentation. Many of the students authentically reflected on their Genius Hour journey and how it had changed them. Students expressed personal change in terms of expected school behaviors such as time management and organization, but also in components of their identity such as the establishment of new interests, passions, hobbies, career

directions and mindsets. Such changes could only be possible with sustained self-awareness and self-reflection. The self-reflection that takes place in Genius Hour is a product of the instructional design and is cultivated by the concepts of 'radical autonomy' and 'purpose'. When students are asked to meaningfully engage with learning and place this learning in their established set of values, they hold such knowledge closer to their heart.

Theme 2: Cultivation of Passions & a Charged Emotional State. Findings indicate that students who took part in this study indicated were generally 'excited' about their projects (Figure 2). Many students expressed that devoting time towards their Genius Hour project did not feel like work. Current research (Robinson, 2009) suggests that this sentiment is usually expressed by individuals that are 'in their element' where their values and talents are completely aligned with the task they are trying to accomplish. People that live in their element are more productive, happier and more engaged with others (Robinson, 2009). Dewey (1910) drew connections between emotional engagement and the quality and quantity of learning performed by students in his Interest Theory. The principle components of Interest Theory (Dewey, 1910), that students would be authentically motivated to perform tasks, persist longer in the face of difficulty and spend a longer period of time learning were apparent in the students in this case study.

Students participating in Genius Hour appeared more engaged with their work than other school tasks. The librarian and teaching aide commented that students exhibited a much greater degree of on-task behavior in the library while researching their

Genius Hour projects than during other visits. This observation was also supported by qualitative quotes such as a quote by "Cole," who said that he spent "at least 50% more time on his Genius Hour project" than any other forms of school work. Perhaps the strongest body of evidence for the ability of Genius Hour to cultivate passions in students is the activities undertaken by the sub-sample (n=3-8) following Genius Hour. "Ava," who studied the science of snow, participated in a snow camp, "Kay" went on to produce more dinosaur videos and drawings and "Leon" has created his own YouTube channel where he continues his experimentation with the structure of instruments and its influence on sound (Appendix I). In their reflections on their experiences two years after the culmination of their projects, these students remarked that Genius Hour was a pivotal step that set the direction for further learning of their passion.

When one considers all of the quantitative and qualitative data sources for this theme and despite the lack of significant differences on the pre and post surveys, there is a suggested connection between Genius Hour and positive emotions. As indicated in Chapter Two, vertical integration of Dewey's Interest Theory (1910) the Hybrid Identities Theory might suggest interest and positive emotions contribute to identity formation. When we consider identity as a compilation of the stories we tell ourselves (Kapur, 2009), it would follow that the stories we are most emotionally connected to would be the ones that would have the greatest personal meaning. When one considers that each individual has millions of experiences, it is emotion that gives certain narratives more value than others (Howard, 2000) and in essence, magnifies their influence in subsequent interactions. The inherent vulnerability in creating a deep passion-project and

revealing it to the larger community may be the aspect of Genius Hour that accounts for the long-standing and significant influence this technique has on students.

Theme 3: Cultural Acceptance of Uniqueness. The extreme personalization of Genius Hour is supported by the pillars of 'radical autonomy' and 'purpose'. When students create completely unique projects, the inherent message they receive is that they are inherently valuable, their work is meaningful and no one else could make the exact same contribution to the classroom or the world. Ken Robinson (2009) created a metaphor where he argued that human talent is analogous to natural resources which often must be unearthed to know their value. "Leon" stated that his interest in music and "passion was always there, but Genius Hour uncovered it" and the positive feedback he received from the class "increased his confidence to create more videos". Anecdotally, some students and the classroom teacher in this case study commented that the class dynamic had positively changed as a result of Genius Hour and indicated greater levels of happiness with themselves and their peers. After students presented their projects, their peers attained greater insights into the personalities of their classmates and the projects often served as an initial discussion point between unlikely friends.

In many ways, the presentation component of Genius Hour can be thought of as a validation of individual vulnerabilities. If we consider our identity as having many layers, it might be that those things which we are truly passionate about, or the things we are brave enough to say are critically important to our happiness, exist at the core. The revelation of these 'cores' and subsequent praise and acceptance from peers and the community was the component of Genius Hour which appeared to have the most

profound and long-lasting impact on students. Current research on identity supports this observation as elements of identity are strengthened and solidified the most significantly during emotional situations which are considered positive (Howard, 2000). Individuals tend to blame negative experiences on environmental circumstances and despite the fact that components of identity may be contributing factors, these are often overlooked by the individual (Howard, 2000). In the classroom, these findings suggest teachers should facilitate activities that validate positive components of students' identity to cultivate individual growth and development.

Theme 4: Exploration of Interest and Identity. Identity research states that individuals often experiment with new identity components and their more permanent incorporation is dependent on if they are adaptive and beneficial to the individual (Howard, 2000). Genius Hour provides such opportunities for experimentation by facilitating an intersect between personal knowledge and academic knowledge described by Guiterrez (2008) as the 'third space'. "Kay" spoke positively of the opportunity provided to her by Genius Hour to continue to explore and develop her love of dinosaurs. She described several events such as more people talking to her about her passion after they became aware of it as well as praise from her family and peers that likely reinforced and further developed this component of her identity. The merger of technology with her passion of dinosaurs offered new paths of exploration and in discussing her growth throughout the two year study, her technological identity appeared to experience substantial growth as she applied her new found skillset to subsequent projects. Ken Robinson (2009) postulates that many people fail to find their passion simply because

they have not been exposed to an experience that taps into it. Genius Hour, in essence, can provide almost any experience that is highly individualized to each student. This observation was supported in the study by a qualitative comment by "Leon" when he said that Genius Hour afforded him "the opportunity to do anything to the complete expanse of [his] imagination". The exploration of personal interests by Genius Hour may not only serve to further hard skills such as knowledge and technological skills, but softer skills such as self-awareness and strong values which vastly improve quality of life in ways that cannot be assessed through traditional classroom measurements.

Theme 5: Integration of Science into Personal Identity. This study examined identity and self-efficacy in broad terms, but also specifically investigated the influence of Genius Hour on science identity and science self-efficacy. The application of Genius Hour in this study took the form of students examining any topic of their choice through a scientific lens. In essence the challenge posed to the students of creating a project based on "the science of [their personal passion]" laid the ground work for the facilitation of the 'third space' described by Guiterrez (2008). The third space can be described as a time and place where personal knowledge, defined as values, interests, passions, 'street smarts' and experiences intersect with academic knowledge (Lee, 2007). The 'third space' provides students an opportunity to explore new identities. Guiterrez (2008) believes that 'hybrid identities' can emerge from the 'third space' where academic knowledge becomes incorporated into a student's being. The study revealed similarities between Genius Hour and Guiterrez's Hybrid Identities Theory (2008), which suggests

that by facilitating projects and experiences for students that activate their own personal knowledge and combine that knowledge with academic knowledge, a new hybrid identity can be formed. In its formation students learn the value of their pre-existing personal knowledge as well as the value of academic knowledge by seeing authentic contexts for its application (Guiterrez, 2008).

The radical autonomy of Genius Hour provided students an opportunity to integrate science identity into existing positive aspects of their self identities through their individual choice of topics. All students indicated they chose their topic based on previous interest or skill in the study area and curiosity to dig deeper. Some research suggests that identity is formed from retrospective, autiobiographical life-story narratives (McLean, 2015). "Ava," who studied the science of snow, is an avid competitive skier and it is likely she had many well established narratives about snow prior to Genius Hour. From a constructivist perspective, Genius Hour may have added science to the existing and established foundation of her knowledge of snow, capitalizing on her previous positive experiences and feelings and confidence in this area. The current research in identity states that identity is constructed in a similar fashion to other forms of knowledge, where new experiences and information are integrated into one's established identity or challenge the existing schema (Howard, 2000).

Despite the absence of a statistically significant increase in students' response to "I see myself as a scientist" (Table 7), students in this study revealed qualitatively that Genius Hour helped them to reframe what they thought of science as a discipline and see some of their personal ways of thinking as scientific. One of the more interesting

findings of the study was that it appeared Genius Hour made science more ‘palatable’ for students as many of them had preconceived misconceptions such as “science is for losers”, “I’m not smart enough to be a scientist” and “science is boring”. Extending this idea, if we hope to see more individuals in STEM fields in the future to meet society’s demand (National Research Council, 2016) , the first step may be to bring the joy of discovery back into science, which may be accomplished through the pairing of personal interests and academic knowledge during Genius Hour. After the students’ participation in Genius Hour they saw science as a “way of looking at the world” and a set of skills to help them further their personal passions. Recall from the research on identity that individuals only tend to integrate positive experiences into their identity (Howard, 2000); therefore it seems that to develop science identity, students must first see the discipline of science as something valuable.

In Chapter Four, two personal narratives of students in the longitudinal study who experienced changes in their career paths as a result of their Genius Hour project were detailed. At the time of this publication “Leon” is planning on combining his musical passion with science to pursue a career in engineering musical instruments and “Ava” is investigating the possibility of combining her love of the outdoors with science to study climate science. The science hybrid identities created by “Ava” and “Leon” in the context of this study is of critical importance to STEM research as Genius Hour may provide a mechanism to facilitate the concept of Guiterrez’s ‘third space’ (2008), thereby increasing the number of students pursuing STEM careers. It is important to note that the goal of this Genius Hour project was not to create a battalion of future scientists, but

rather for students to explore their identity and to facilitate an experience where science may find a place of greater importance in students' previously established identities.

In current science identity research, the paradox whereby students may demonstrate scientific competencies, but fail to see themselves as scientists is an emerging theme (Tucker-Raymond, Varelas, Pappas, Korzh, & Wentland, 2007). The implications of this study (Tucker-Raymond, Varelas, Pappas, Korzh, & Wentland, 2007) suggest that developing competencies and skills alone may not be enough to draw students into STEM fields and that purposeful science identity development may cultivate more future scientists. To this end, Genius Hour may be an instructional invention whereby opportunities to develop both scientific competencies and science identity in tandem are provided.

Self-Efficacy Themes

Theme 6: Effort, Time and Immersion. The proposed schema (Figure 3) suggests that the component of Genius Hour theorized in this study to promote self-efficacy was 'mastery'. Students indicated qualitatively that they "devoted more time to Genius Hour than other tasks" and prioritized it "because it didn't feel like work". Additionally, the devotion of 20% class time during the week to developing their Genius Hour project provided many opportunities for mastery. Perhaps the most compelling argument for the positive influence of Genius Hour on mastery was revealed in the longitudinal study where students independently pursued additional personal projects to further develop their skills. This finding suggests that while Genius Hour is a large investment up front,

this investment may pay far greater learning dividends after the culmination of the project. Further, findings from data analysis from the sub-sample indicate that all students devoted exceptional amounts of time to the creation of new animations, new videos and participation in snow camps. The students were intrinsically motivated to continue honing their skills to such an extent that two students in the sub-sample altered their proposed career paths as a result of participating in Genius Hour. Therefore, an expanded study that closely examines the amount of time students spend after the culmination of their project, and the way in which they work on it and the types of skills they develop would be useful in making a stronger case for the use of Genius Hour in the classroom. There are few tasks in a student's school career that stimulate this level of sustained dedication. This finding is significant to educators that may be reluctant to establish 20% of their classroom time for Genius Hour. Many may find it surprising that such experimentation and creativity can carry on in their absence without the tangible reward of grades. For educational reformists, the type of learning that takes place during Genius Hour, learning which students choose to immerse themselves in and devote themselves to, is what schools should aspire to cultivate (Holt, 1989; Robinson, 2007).

Theme 7: Cultural Acceptance of Effort. Current research suggests that self-efficacy can be developed by praising efforts and behaviors over final products and reframing learning as a journey rather than a destination (Dweck, 2006). In this study most students indicated that they felt their Genius Hour project was substantially more work than other tasks that they were doing in school, but that it felt enjoyable to work on. One interesting finding was the level of involvement of parents, friends and people in the

community with students and their projects. One student, "Sal," who studied the science of skiing, visited a local ski manufacturer in town and came out of the Genius Hour experience with a trusted adult mentor that shared his passion. This student indicated they felt proud when they revisited the store and showed the owner their Genius Hour project. "Ava" has had her video documenting the dangers of avalanches used by the local university to teach international students about snow safety. Many of the students showed their videos to distant relatives who provided them with praise. Such experiences demonstrate to students the value of hard work in a personally meaningful way. The praise the students received for their efforts "made [them] more driven". One of the clear advantages of having the students present their project in video format was that it provided a mechanism to disseminate their findings and resulted in greater acknowledgement of their efforts and talents from a larger audience. The cultural acceptance of effort can change the self- narratives students have when they begin to internalize, external comments telling them they did a good job and worked hard (Howard, 2000). Such a finding relates to self-efficacy as 'a belief in one's self' may be the product of self-talk regarding perceived success or failure at similar tasks.

Theme 8: Resilience & Self-Reliance. Resilience, a component of self-efficacy, is a skill where one adapts to and rises above challenges (Vygotsky, 1962). The Science and Engineering Practices (National Research Council, 2016) may be considered tools to help students face scientific challenges. The quantitative and qualitative results of this study indicate a correlation between Genius Hour and the development of at least two of the Practices.

Findings from this study suggest that two of the Science and Engineering Practices (National Research Council, 2016) had significant, although small increases (Tables 9, 10). When one considers that the Genius Hour instructional technique is largely inquiry-based, it is not surprising that the Practice of "asking questions and defining problems" would be the practice most likely to experience a change by the culmination of the project. Likewise, the students had to perform considerable amounts of research for their projects which may have contributed to a statistically significant improvement in the Practice of "analyzing and interpreting data". These results are also supported by the many qualitative comments made by students where they shared they were challenged by Genius Hour to define their project for themselves. From a broader perspective, the development of science self-efficacy may increase global self-efficacy for students as it contributes to their ability to address challenges across many contexts.

In this study students indicated they found Genius Hour challenging because there were no easy answers and that they were the expert on their particular topic. In a passing conversation one student said that if they encountered difficulty on a worksheet they could just ask their friend or teacher for help with a question and because everyone was doing the same work, a single correct answer was established and with Genius Hour the answers were less clear. The nature of the work of Genius Hour cultivated self-reliance and resilience in students. Assistance from teachers usually took the form of asking questions to help students clarify their problem and what they had thought of as possible solutions where the teacher would help the student reason through each proposal to find an appropriate course of action. It would be useful for subsequent research on Genius

Hour to provide detailed practical strategies for using such effective questions to help students to work through problems on their own. Had this study taken place with a less experienced teacher, there may have been an inclination for the teacher to immediately solve the students' problems instead of modeling problem-solving behavior.

It is also important to note that students may have demonstrated more resiliency and self-reliance in their Genius Hour task than other tasks because they already had some measure of success with their passions and this self-confidence may have enabled students to persist through difficulty. However, it is also important to note that students did feel challenged by the project and perhaps their initial skill basis ensured that their project was in their zone of proximal development (Llewellyn, 2007). "Leon" repeatedly made statements throughout the longitudinal study that there were many ways to demonstrate and apply knowledge in Genius Hour and that indictors of quality were based on personal value choices. One possible explanation for the creative choices the students made and their ability to be innovative in this project was that they began their project from a place of comfort as something someone regards as a passion they usually have intimate familiarity with. Perhaps resiliency can be best cultivated when students pursue activities where they have an initially strong foundation from which to draw strength as they venture outside of their comfort zone.

Summary Review of Research Questions and Findings

The previous section reviewed the major themes uncovered in this study. This following section will succinctly summarize the findings in relation to each research

question in an attempt to review conclusions prior to making recommendations for further research.

How does Genius Hour influence identity and self-efficacy in high school science students? As indicated, the three pillars of Genius Hour as defined by the motivational theory of Daniel Pink (2011) are autonomy, mastery and purpose. The features of Genius Hour that relate to the development of identity are autonomy and purpose while mastery most strongly supports self-efficacy. The findings of this case study indicate that Genius Hour provides an opportunity for students to connect with existing components of their identity by choosing a project they are passionate about. Additionally, Genius Hour provides opportunities for the exploration of new identities and passion as the students take their projects in different directions and develop new skills such as "Kay" did in her Claymation of fossilization project. The Genius Hour instructional technique cultivates 'hybrid identities' in students by establishing the 'third space' (Guiterrez, 2008) where personal knowledge and academic knowledge can interact. When students attained acceptance of their hybrid identities through conversations with peers, feedback from teachers, parents and the community and through their own appraisal as to whether their project reflected their values, their self-confidence in revealing their identity to others increased.

Genius Hour developed self-efficacy in students mainly through mastery opportunities created by merging home and school. It is important to recognize the 'third space' (Guiterrez, 2008) is not only cultivated at school, but students also utilize a time and space already established for their personal interests at home to integrate academic

knowledge through their project work. Such a merger increases the number and quality of meaningful conversations the student has about their work, thus providing more opportunities for practice. Such conversations may also provide positive feedback and acceptance of the students' effort and skills. Self-efficacy is connected with tangible skills and success so it follows that the more practice opportunities a student has, the stronger their hard skills will be, providing them with increased self-confidence in their abilities. This statement was supported in the study by the significant increase students had in their appraisal of 'science is something I am good at' and their ratings on the Science and Engineering Practices which indicated significant increase in 'asking questions and defining problems' and 'analyzing information'. Another line of evidence from this study that indicated mastery was occurring was the increase in the relative number of students indicating feelings of competence as the project progressed (Figure 2). In addition to mastery, the highly individualized nature of the Genius Hour projects encouraged resilience and self-reliance as each student was the expert of their own topic and had to construct their learning. It is important to note that gains in reliance and self-reliance are contingent upon the teacher acting as a guide on the side, modeling problem solving thought processes alongside the students than existing as the sole source of knowledge.

How does Genius Hour influence science identity? The first question in this study examined identity broadly, but current research indicates that individuals hold epistemic beliefs, sets of beliefs that are activated in certain contexts and not others which are influenced by their values and perceptions of science as a discipline (Halloun, 1998),

therefore it was important to separately examine the influence of Genius Hour on science identity and science self-efficacy. Qualitative statements throughout the study indicated the enjoyment the students experienced positively altered their view of science which likely made its integration into students' identity more likely. Recall that identity components are only integrated if they are adaptive and viewed as valuable by the individual (Howard, 2000). Redefining science as valuable and something attainable by students is likely the first step in identity development. Such research may also reveal a relationship between identity and self-efficacy in that as competence and confidence are developed in the field of science, the resulting positive feelings and feedback from others may increase the likelihood of the formation of a 'hybrid identity', described by Guiterrez (2008).

How does Genius Hour influence science self-efficacy? Research in the epistemic beliefs regarding science suggests that students view science as a set of skills and knowledge that is really difficult with few individuals adept at science (Halloun, 1998). Genius Hour reframed science as something they were capable of as evidenced by student comments which revealed that they were "doing many scientific behaviors accidentally without realizing it". Students that will not likely pursue STEM fields did develop the ability to look at the world through a scientific lens. The entire student sample (n=136) showed a statistically significant increase in their overall perception of scientific ability (Tables 9, 10) and in the Science and Engineering Practices of 'asking questions and defining problems' and 'analyzing information'. As a main goal of the Science and Engineering Practices is the transferability of these skills to many contexts

(National Research Council, 2016), all students, regardless, of their intention for STEM careers, benefit from the development of these skills. Additionally, science self-efficacy was developed during Genius Hour because the inquiry-like nature of this instructional technique has a strong alignment with the real nature of science that embodies trial and error, asking questions, seeking assistance from community resources, creativity and innovation. Qualitative comments in the study supported this statement as students in the longitudinal study indicated that they had previously saw science as rigid and highly specific and after Genius Hour they realized it was more expansive and less delineated.

This study demonstrated through many quantitative and qualitative sources of data that the instructional practice of Genius Hour does influence identity and self-efficacy as well as science identity and science self-efficacy. The longitudinal component of the study provided rich data which suggested there was no extinction of the educational benefit (which is often the case), but rather a magnification of its influence over time as students continued on the learning journey of the exploration of their passion.

Alignment of Genius Hour with Millennial Learners

When one considers the stages of development, the teenage years are a time of self-exploration and identity formation (Elmore, 2013) which may account for part of the proclivity of teenagers to embrace Genius Hour. However, the extreme personalization of Genius Hour seemed to align with the larger cultural trends in North America at the time of this study, particularly the values and traits of the millennial generation.

'Millennial' is the term describe anyone born between 1984 and 2002 (Elmore, 2012). The later cohorts of this generation, those born after 1990, are often described as digital natives as they were born into a highly technological world. Part of the digital movement has been the increasingly personalized landscape that values individualism (Elmore, 2013). When one considers i-Tunes, i-Pods, i-Movie and i-Phones the precipice of this marketing strategy is the celebration of uniqueness of the user. Tim Elmore (2013) coins this cohort as 'generation iY' and makes the case that the 'I' is king with this group of young people who are often deemed to be narcissistic and self-absorbed. He notes their lack of skills, namely resiliency and responsibility, is the direct result of over-parenting and over-protecting. He goes as far to predict future flagellation and disenchantment for these young people. Elmore (2012) theorizes that many young people possess 'artificial maturity' and he describes in his book by the same name, that teachers and parents often pre-digest or delineate tasks too heavy-handedly and inadvertently undermine real opportunities for growth. The findings of this study on Genius Hour may interact with Elmore's work in two main ways. First, his insights into Generation iY may explain why the 'radical autonomy' component of Genius Hour is so appealing to students. And secondly, the findings from this study in regard to identity and self-efficacy suggest Genius Hour may be a way to answer Elmore's plea for teaching strategies that promote authentic independence.

Elmore's work challenges the influential adults in the lives of Generation iY to expose them to authentic challenges with little adult assistance. The comments of students during the Genius Hour process often lamented on how challenging the project

was and it was not until the project culmination that their view of the challenge changed from an imposition to a rewarding experience. Many students indicated that they had more pride in their Genius Hour project than any other work they had done in their entire school careers. "Guy" a zesty, outspoken and opinionated student said "all the other things I've done were what someone else wanted and they don't value the same things I do, this project was the best work I've done, it was all me and it was awesome". In comparing the Genius Hour project to more traditional academic tasks "Ava" indicated she "had to flex their own muscles more" and take on more responsibility. The findings of this study indicate that Genius Hour is a mechanism to increase the real skills and self-efficacy Elmore (2013) believes is in short supply among young people. Central to Elmore's work (2013) is a description of a set of values unique to millennial learners summarized in the acronym SCENE, whereby he describes millennial learners as typically valuing speed, convenience, entertainment, nurture and entitlement. Genius Hour may encourage growth in these areas. Due to the emphasis on mastery of the Genius Hour instructional technique, students may grow in their ability to work hard at a task over a long period of time and be more personally responsible for their learning. In this study on Genius Hour, most students expressed pride in their work which many described as "the most substantial work [they] had ever done." The creation of a Genius Hour product, created through a long and challenging process, may help student reframe their views of labour and efficiency. Additionally, the 'radical autonomy', where students are given the opportunity to make many learning choices, may help them gain a greater tolerance for taking risks. Finally, the belief that 'boring is bad' (Elmore, 2013)

may be addressed by the conceptual underpinnings of Genius Hour where academic knowledge is integrated with personal knowledge in the 'third space' (Guiterrez, 2008). When students are creating projects that they are innately curious about, they may see the value of traditional knowledge which can be used to help them gain a deeper understanding. For example, in this study, a student who studied the science of skateboarding and was described by the classroom teacher as a student that hated school, began to see the physics behind different types of skateboards and used his knowledge to further his skills. During his presentation to his peers, he described how he was experimenting with wheel placement to perform various stunts and said that he "finally found the concept of turning radius was actually pretty cool." Future research in this area may include an instrument which assesses students on Elmore's (2013) values which could be administered before and after a Genius Hour project. Additionally, to provide a more quantitative rationale for the use of the Genius Hour instructional technique, validated pre/post surveys that focus on student engagement could be used in future studies.

In a review of post-Genius Hour whole class reflections, 98% of students indicated one of the things they liked best about Genius Hour was their ability to choose their own topic, while 2% indicated being able to choose anything was 'overwhelming' because they had little experience with that kind of openness. In qualitative comments, students cited the radical autonomy in project topic and approach as the principle reason why the project was engaging and they were interested in it. Students indicated they "loved the freedom of choice", described Genius Hour as an "opportunity to learn

something to the expanse of your imagination". The personalization piece of Genius Hour was very important to the study participants and their receptivity to this type of autonomy, may be attributed to the characteristics of Generation iY described by Elmore (2013). However, Daniel Pink (2011) believes that students and workers of all ages are more motivated to achieve when they are given opportunities for autonomy, mastery and to fulfill their purpose, suggesting the principles of Genius Hour are of universal benefit. Robinson (2007), an educational reformist states that while the culture of personalization is strong in our everyday interactions and the workplace, there is little alignment with our current educational approach, one that has existed relatively unchanged since the Industrial Revolution (Robinson, 2007). Genius Hour may not only be an instrument to increase student investment and engagement, but also of educational reform.

Implications for Research

Genius Hour is a newly emerged instructional technique. Therefore, the opportunities for further research in operationalizing the technique and refining it for different subject areas and further situating the mechanisms at work within established educational theories, are abundant. Throughout this study, as the researcher gained insight into the workings of Genius Hour, more questions arose than answers were discovered.

Contextual Investigations

There is a substantial amount of further research that can be done to examine the nuances of Genius Hour and its influence on learners of all ages. This instructional technique can be used across disciplines and grades and it would be useful to develop some precision in implementation of best practices for different contexts and different types of learners. While there is a wealth of best practices in informal practitioner discussions, formal testing of the efficacy of these practices and their generalizability may serve to increase the effectiveness of Genius Hour. Additionally, if there were subject-specific research available regarding the effectiveness of this strategy, there may be more investment in Genius Hour from reluctant teachers and administrators. Genius Hour may be able to co-develop subject specific goals such as inquiry in Science, the examination of primary sources in Social Studies and innovation in elective classes such as Fine Arts and Entrepreneurship. Subsequent research on Genius Hour may follow a similar trajectory to project-based learning where the global concept and aims were introduced and as educators began implementation, refinement of the strategy occurred as teachers applied the principles to different contexts. An eventual blend of the project-based learning instructional technique and the unique 'ways of knowing' associated with each subject discipline has emerged in the current educational landscape and consequently, greater acceptance of the efficacy of this practice has occurred (Blumenfield, 1991).

Furthermore, formal research on the positive effect of project-based learning on student performance greatly increased its acceptability in the classroom (Colley, 2008).

As Genius Hour is a type of project-based learning, it follows that parallelism could exist between the acceptance and wide-spread implementation of Genius Hour and project-based learning. It is important to note that the historical path of project based learning from a global construct to increasingly subject specific practices (Blumenfield, 1991) was an important consideration in the formation of research questions in this study. The dual purpose of the study was to examine the broad implications for identity and self-efficacy and also examine the influence of Genius Hour on science identity and science self-efficacy. The further refinement and operationalization of Genius Hour will likely aid in the strategy's successful implementation and perhaps, also serve to enhance the existing aims of each subject.

Additionally, it would be beneficial to determine which types of learners benefit the most from the Genius Hour instructional technique and to describe the skills developed in each type of learner and how they are developed. In this study, high achieving students typically struggled with the 'radical autonomy' of Genius Hour as these students were accustomed to success at meeting the criteria set by others. For these students, the risk-taking element of Genius Hour was a very complex challenge to overcome and many high achieving students reported an internal struggle in deciding what their indicators of quality would be for their project. Such information assists teachers in developing strategies to mitigate challenges presented by specific types of learners and aids in differentiation and customization of support. It would also be interesting to uncover the internal dialogues through qualitative interviews of struggling students, students with learning challenges, gifted students, male students vs. female

students, older students vs. younger students and the like. Such comparisons may provide insight beyond practitioner implementation in the classroom and answer higher questions such as 'when do students become inhibited in their academic risk taking?' 'What personal characteristics do the most innovative and creative students have and how are they developed?' If our current educational goals are intentioned to be transformative and yield new types of learners (Robinson, 2010), these questions are worthy of vigorous subsequent research. Finally, research into teachers and their ability to execute Genius Hour, how they are personally changed by Genius Hour and the personal characteristics the most effective Genius Hour teachers possess would also be useful in refining this educational practice and increasing its effectiveness.

Cultural Acceptance of Pop-Educational Trends

One of the most fascinating aspects of this study was the widespread acceptance and the almost cult following of Genius Hour among practicing teachers in the relative absence of peer-reviewed research on the efficacy of this technique. The information that exists on Genius Hour is found on YouTube videos (Juliani, 2014; Kessler, 2014), webinars (Kesler, 2016), blogs (Krebs & Kirr, 2013), Facebook groups (Juliani, 2017) and practitioner oriented books (Juliani, 2014; Wettrick, 2014; Krebs & Zvi, 2015) Instead of a traditional 'top down' trend in which researcher work is used by educational leaders to guide teachers' practice, there is more informal and haphazard teacher to teacher dialogue regarding best practices. In the review of existing Genius Hour resources this study noted that teachers were passionate about Genius Hour and that

many teachers fully bought into the technique without formal vetting. Genius Hour could serve as a phenomenon in which to investigate why teachers will fully accept some educational techniques and not others, how the method and communication of the technique affects teacher interest and passion and perhaps how formal research can be more easily dispensed to practicing teachers than through traditional journal publications.

Perhaps the 'autonomy, mastery and purpose' pillars of Genius Hour speak not only to students, but also teachers by respecting their professionalism and uniqueness more so than highly prescriptive educational techniques. Such investigations may help determine what types of research are valued by educators, which is of critical importance because without implementation, educational research has no lasting effect on students. An interesting subsequent application of Genius Hour would be a Genius Hour approach to teacher professional development. If teachers possessed the radical autonomy to pursue their personal professional passions, how might this impact their teaching practice? their level of job satisfaction? their ability to execute Genius Hour in the classroom to their students? As a former principal, I feel that sometimes teachers are not afforded the same level of thoughtful pedagogy that we strive for with our students and that sometimes, just as the case in the classroom, accountability trumps all else. Genius Hour is built on the premise of trust; teachers trust the innate curiosity of their students and their desire to put their best work forward. If this same trust was afforded to teachers in their own professional development we may see similar outcomes found in students participating in Genius Hour, namely increased engagement, development of metacognitive skills, development of greater self-efficacy and a stronger sense of

identity. Again, if we are to respond to the call for transformative educational change (Robinson, 2010) it would be worth re-examining not only practices that take place in the classroom, but also re-examine teacher education.

Genius Hour Explained Through Cognitive Constructivist Lens

Piaget's cognitive constructivism theory describes a premise where all new learning is formed on the basis of past experiences and knowledge. This would be a fitting paradigm to examine the component of Genius Hour where students select a topic based on their personal passions and interests. Lee's (2007) extension of this theory in his description of 'funds of knowledge' could also be applied to see how students' previous experiences, in both the personal and academic realm, help shape their project. Substantial research could be done on Genius Hour to evaluate the quantity and quality of each student's preliminary 'funds of knowledge' and the subsequent influence on student competence, self-efficacy and identity communicated in their projects. Additionally, valuable insight could be gained from studying how the process of Genius Hour builds, solidifies and or challenges existing 'funds of knowledge in students to further their learning. From a practitioner's perspective research could be done to determine best practices for activating students' prior knowledge and to determine which types of knowledge and skills may be the most useful in project based learning techniques such as Genius Hour.

Genius Hour Explained Through a Social Constructivist Lens

In contrast to Piaget's theory of constructivism (Moll, 1992) which focused mainly on individual learning, Vygotsky suggested that learning takes place through conversations, experiences and interactions with others. This theory puts more weight on the affective domain of learning (Moll, 1992), whereby learning is more likely to be solidified if students are in a positive emotional state. This theory could be applied to examine the following components of Genius Hour: student interactions during project selection and development in the classroom, in the home and the influence of the final presentation component at the culmination of the project.

During the project creation students have conferences with their teacher and their peers to discuss their project progress and problem solve any difficulties or setbacks. The meaningful conversations that take place between student and teacher may help extend student learning by asking effective questions and posing challenges and alternative viewpoints to the student. For example, a student building a catapult may make their initial design out of steel and their teacher may ask the student about their thoughts regarding the role of flexibility in materials in transferring maximum force to an object or show them conceptually challenging phenomenon such as a slow motion video of a golf club flexing before striking a ball. Similarly, peer to peer interactions may stimulate activation of previous knowledge while students share their experiences with each other. Students may also draw on expertise and the collective knowledge of family and community members.

Such conversations could take the form of reflecting back on shared experiences such as family vacations and once this knowledge base is activated, the collective observations and conclusions are applied to the new challenge of Genius Hour. Genius Hour may provide more substantive talking points for students and families than rote tasks such as worksheets or recall tasks. The influence of these conversations during the learning task provides many opportunities to study how such interactions influence the saliency of the learning that occurs during Genius Hour. In addition, research could focus on how the interactions influence student engagement and persistence on a task, how talking about one's passion contribute to its development and how the interactions affect assimilation of the material learned during Genius Hour into the students' identity.

Genius Hour creates opportunities for extended meaningful conversations. Vygotsky (1962) also notes in his social constructivism theory that learners have private conversations with themselves which influence and direct their learning. The researcher applied the concept of private and public interactions (Vygotsky, 1962) to situate Genius Hour in the social constructivism school of thought and developed the following schema which hypothesizes how the many 'conversations' that take place in Genius Hour may assist in developing self-efficacy and identity in a science classroom. The following figure (Figure 4) provides a proposed framework for those interactions.

The schema attempts to integrate the research by both Piaget and Vygotsky to explain Genius Hour, where learning occurs through conversations with one's self and interactions with others. 'Private Interactions', as described in the schema, encapsulate the internal dialogue a student has throughout the project. Conversely, 'Public

Interactions', describes the students' interactions with their peers, teacher and community members. The interface between the private and public domain is the Genius Hour project, where the project itself, is a manifestation of internal values and passions of each individual student. Because the project is based on components of the students' existing identities, the acceptance or rejection of the project can be seen as an acceptance or rejection of the components of the students' identities they put into their projects.

For the construction of a new science hybrid identity to occur, two criteria must be met: the student must see their project as valuable, based on their own indicators of mastery and their project/science identity must be accepted by teachers, peers and the community. If both these conditions are met, the student may integrate 'science' into their established identity. If student work is rejected by teachers, peers and the community, there is significantly decreased likelihood the student will integrate science into their identity as current research has established, negative components of identity are often rejected and such traits are attributed to external circumstances than personal characteristics (Howard, 2000). Additionally, if a student receives accolades and acceptance from others for a project they do not deem to be personally valuable, the establishment of a new, hybrid identity is not likely. The schema ultimately suggests that for science identity to be cultivated, science work must not only engage cognitive skills, but also challenge and activate the individual values of students.

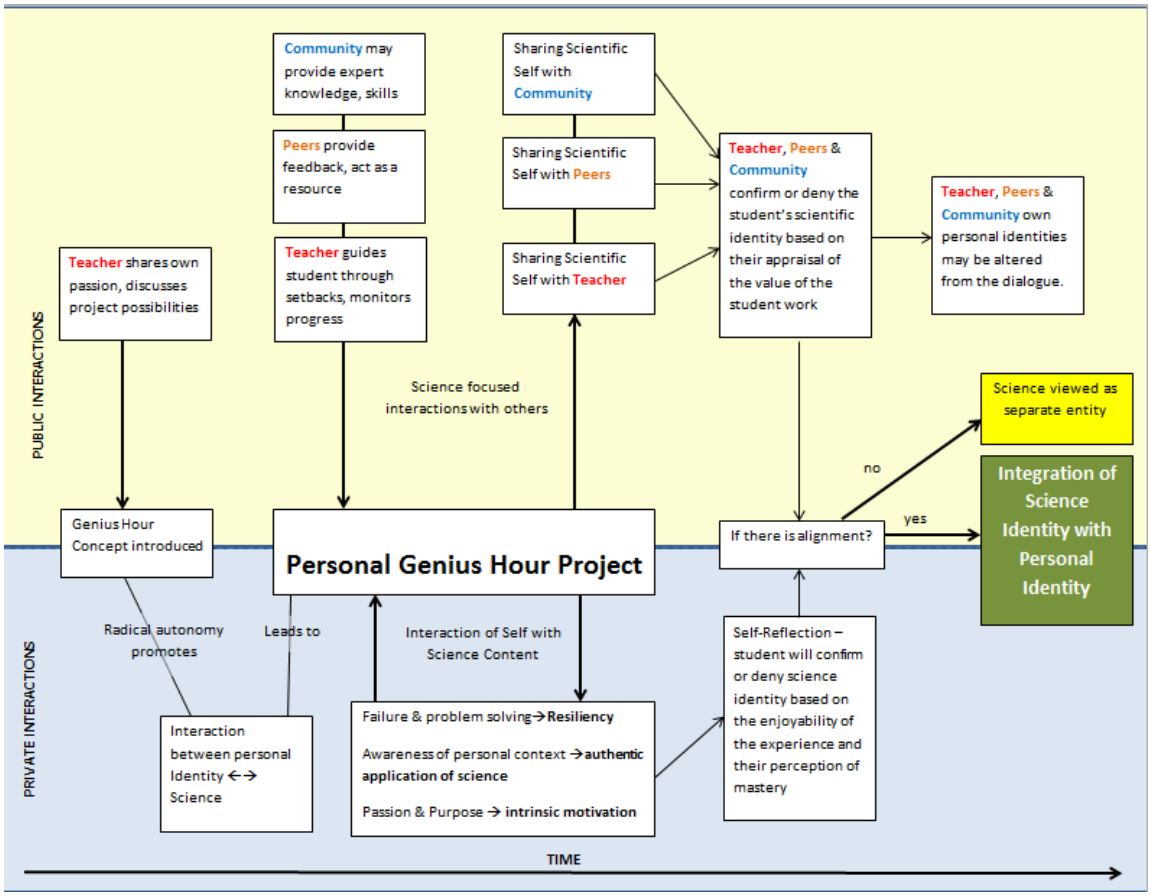


Figure 4. Proposed Genius Hour schema describing the role of public interactions and private interactions in identity development.

The accuracy of this proposed schema in explaining the processes at work in identity and self-efficacy development during Genius Hour need to be further vetted and investigated. To ascertain what is occurring during the students' private interactions with themselves, analysis of video journals throughout the Genius Hour process may provide valuable data. Likewise, video of students interacting with their teacher and their peers and community throughout the process would allow the researcher to investigate the content of these conversations and perform an emergent thematic analysis. By focusing research on the mechanisms at play during the Genius Hour process and their saliency,

further research can hope to determine which aspects of the technique should be adhered to with total fidelity and which aspects can be modified effectively.

One striking finding of the research performed in this study was the meaning assigned to the conversations regarding the final presentation of their project by the students. Students described an overwhelming sense of accomplishment, but some also commented that it was a validation of their skills, talents and even who they are, when their project was warmly received by their peers. Recall that "Leon" in his conversations following Genius Hour and throughout the longitudinal study, continued to return to the idea that the validation he received from his peers gave him the confidence to more fully reveal himself, his passions and his talents to others. One unexpected outcome for the researcher was the value "Leon" assigned to the continued meetings and interviews throughout the longitudinal study where the researcher asked for reflection on Genius Hour and "Leon" poetically reflected:

> When you think back to your project and emotions you were feeling, the process and the final product and what you have produced since then you realize what you are capable of…. it is hard to look at success from the opposite end- once you are past that point and striving for more, it is pretty easy to forget how far you've come- the meetings have slowed things down and made me think about where I came from instead of just where I am going to go next.

Such reflective conversations following Genius Hour could provide great insight into practices that solidify the gains made during the Genius Hour process. This component of the Genius Hour process could draw in the literature on mindfulness and metacognition. In terms of social constructivism, a researcher may explore how the periodic activation of past successes through dialogue may enhance the cognitive base for

subsequent learning and provide opportunities for students to create more connections between their experiences.

Genius Hour Explained Through Growth Mindset

Carol Dweck's (2006) recent research on the growth mindset has a strong alignment with the inquiry-like nature of Genius Hour. In Dweck's construct (2006), students who possess the growth mindset define learning as a continuous process where setbacks are viewed as opportunities for growth and conclusions lead to new questions. Conversely, students with a fixed mindset are performance-oriented and their self-efficacy is heavily influenced by external appraisals of their work (Dweck, 2006). The application of the growth mindset to Genius Hour is fitting as during the Genius Hour process students are in the driver's seat of the learning which includes confronting challenges and addressing limitations (Kesler, 2014). In this study, many students commented in group interviews that weaknesses they were not aware of were revealed as they navigated their projects independently. They found their projects challenging, but also observed greater dedication to their Genius Hour project than other homework in terms of both time and effort with one student remarking he "spent more time on his Genius Hour project than all other homework combined". "Ava" from the sub-sample group reported having greater persistence in the face of difficulty while working on Genius Hour tasks because there was no expert readily available to answer questions that were unique to her project on avalanches. She also commented that the indicators of quality for her project were largely self-constructed and it was up to her to close the gap

between where her project was at at any given moment and what she hoped it would be. Challenges were not deleterious to her work; rather they were opportunities for learning. Dweck's original research (2006) focused on personal traits possessed by individuals that possessed resiliency, self-efficacy, grit and persistence (the growth mindset), while subsequent research and application of her work in the classroom is centered on fostering the attributes of the growth mindset in students (Ricci, 2013).

Because Genius Hour provides an opportunity for autonomy and therefore, responsibility and accountability for overcoming inevitable challenges (Juliani, 2014), it may be a technique that can foster the growth mindset in students. Students who possess a growth mindset are more likely to be innovative and take academic risks than those with a fixed mindset (Ricci, 2013), which is of special interest in science where the true nature of scientific investigation requires a willingness to participate and overcome the disappointments with trial and error (Tas, 2010). Using educational techniques which promote the growth mindset, especially in the sciences, may increase student self-efficacy and their pursuit of STEM careers. A possible way to address the shortage of STEM students may need to focus on creating students who demonstrate success in the sciences, but who are also capable of dealing with 'failure' and 'imperfections'. Perhaps the most telling piece of information from this study that shows a relationship between the Genius Hour and the growth mindset is from "Leon" a reflective student with quiet confidence. He said during a small group interview

> …usually you are in a situation where you are judged for your imperfections, but it is the imperfections are what make you interesting to someone else… I got to fully express who I am… Genius Hour lets you pinpoint who you are and what you enjoy-, but, it isn't just about you- its providing for other people and letting them learn from your experiences.

The raw authenticity expressed in this quote demonstrates a student willing to accept himself and have enough confidence to show all dimensions of himself. Additionally it is an acknowledgement that the Genius Hour project redefined imperfections as badges of uniqueness instead of indicators of diminished quality. It suggests the open, inclusive and student defined criteria for Genius Hour may encourage students to take greater academic risks and strengthen their growth mindset. Subsequent application of the research surrounding the growth mindset in Genius Hour may help us understand how this technique develops self-efficacy and resiliency.

Implications for Practice

Genius Hour & Educational Reform

Sir Ken Robinson (2010) and others (Holt, 1989) suggest traditional models of schooling rob students of their creativity by their strong emphasis on compliance, teacher-directed learning and uniform expressions of competence in standardized testing. Both Holt (1989) and Robinson (2010) suggested that the greater architecture of our educational system requires substantial changes to promote creativity in the classroom and the reach of educators is confined by the institution of school. This may account for practicing educators limiting the 'radical autonomy' promoted by idyllic conceptions of Genius Hour found in this study. If teachers must work within the constraints of

accountability culture, they may be hesitant to give control of learning over to their students. Consider also that at the time of this study Genius Hour was an emerging educational practice and the definition of "radical autonomy" may mean different things to different teachers. If we assume a graduated shades of grey spectrum exists between teacher-centered classroom and student centered classroom which promote 'radical autonomy', even though teachers landed at different positions on the spectrum, there was consensus that Genius Hour was a shift towards a more student-centered classroom in the practitioner accounts (Krebs & Kirr, 2014). Additionally, some teachers may be more conservative in trying new teaching techniques. Some teachers may feel confident enough to jump into new teaching techniques while others must first get a proverbial toe wet. Over time, the acceptability of Genius Hour in the classroom may improve and as teachers get more familiar with the technique they may be more willing to venture towards 'radical autonomy'.

The pillars of 'mastery' and 'purpose' described by Pink (2011) had greater consensus among practicing teachers in the survey of Genius Hour resources. It is possible these components were more palatable as they are integral components of project-based learning, which has been in place for longer and is further developed than Genius Hour (Juliani, 2014). While Genius Hour is arguably a form of project-based learning (Juliani, 2014), its uniqueness pivots entirely on 'purpose' and the 'radical autonomy' to integrate one's passions into learning. Therefore, the variability in radical autonomy in respective Genius Hour classrooms may not be a rejection of this concept, but rather a reflection of an underdeveloped skill in teachers new to Genius Hour.

Research suggests that teachers with greater teaching self-efficacy have greater trust in their professional judgement and are more willing to take risks in the classroom (Aschbacher, 2009). If the pillars of autonomy, mastery and purpose are established motivational factors (Pink, 2011), it may follow that if we should also extend the principles of Genius Hour to the professional development of teachers.

The classroom could be reconceptualised as a third space for teachers where they bring their personal passions to life in front of their students. In such a scenario, teachers would model how the merger of personal and academic worlds may occur. In STEM fields this is particularly important as it may serve to 'humanize' what it means to be a scientist, as the concept of 'scientist' is often something foreign that students do not identify with (Aschbacher, 2009). Teachers demonstrating the 'third space' (Gutierrez, 2008) in their own personal practice may reorient students towards one mindset that is supported by research where students see science as a mechanism to fulfill their own purpose and satisfy their own curiosity instead of a set of robotic behaviors determined by someone else (Aschbacher, 2009).

Personal Reflections

The value of a longitudinal study is that you get to see the magnification or extinction of set of skills in students. Additionally, a longitudinal study develops you as a researcher as you sharpen your ability to observe, ask questions, re-examine and draw connections. In an effort to find answers about Genius Hour and how teachers can affect identity and self-efficacy, the researcher was soon humbled by how many questions

emerged and how the process of formal investigation made me re-visit my past experiences.

As a teacher and principal, the researcher has implemented Genius Hour for five years across all age groups. The researcher, in a similar fashion to many of the passionate practitioners, anecdotally noted its efficacy for my students. The researcher saw 'results' when two elementary students heartily hauled in pieces of drywall larger than they were to construct a bobsled. The researcher saw real learning when the aforementioned bobsled fell apart on its maiden run because duct tape loses its charm in the frigid Canadian winter. The researcher saw grit when they rebuilt their sled 4 times, using different materials until they made 'the most awesomest sled in the universe'. The researcher saw pride in their high fives to the older students in the school. There was value in these types of observations and my everyday reflective practice as a professional teacher. As the researcher embarked on her journey to obtain her doctorate, she did not want to look down her nose at these beginnings, for it is in the corner of the copy room, on playground at recess or those stolen moments at teachers' convention where a lot of the real transformative learning takes place for teachers. But just as it is wrong to denegrate her practitioner experience, so too, it is wrong to place her more formal research on the sometimes stuffy shelf of traditional academia. What she hoped to accomplish with her formal study of Genius Hour over the last two years was to sharpen her acuity in describing the student experience of Genius Hour and to somehow capture their voices as they learned. In recording their 'Genius Hour oral histories' and noting the influence of Genius Hour on their identities, the biggest realization from her research

was that teachers are impactful in ways they may not realize. She saw how one six-week project set career trajectories for some students that they never would have entertained without the freedom of exploration afforded to them by Genius Hour. She saw students become emboldened to reveal previously concealed parts of themselves to the world. And in these moments of raw authenticity, when students chose to be 'big' in the world, she saw teachers and students alike moved to tears. How many educational techniques can be this transformative for students? This phenomenon alone underscores the value of further research of Genius Hour.

I hope to continue my longitudinal research with "Kay", "Ava" and "Leon". Looking back at the changes set in motion since the culmination of Genius Hour in 2014 it is difficult to have anything but overflowing optimism for their future.

Conclusion

This study examined the influence of the Genius Hour instructional technique on identity and self-efficacy in a high school science class. While the quantitative findings of this study had some insignificant results, exit card data indicated students had mostly positive emotions towards Genius Hour and indicated increased competence over the course of the project (Figure 2), while survey data indicated a significant increase in students' self perceptions of their ability to do science (Tables 5, 6, 7), particularly the Science and Engineering Practices (National Research Council, 2016) of 'asking questions and defining problems' and 'analyzing and interpreting data' (Tables 9, 10). Qualitative results had greater consensus and indicated that Genius Hour had many

positive impacts on identity and self-efficacy. Students reported the exploration of their interests during the Genius Hour project increased their self-confidence through the acceptance of their projects by their peers, enabled them to consider and pursue alternate career paths and developed many transferrable skills such as time management, goal setting and resilience. From the review of the literature, there is evidence to suggest a connection between self-efficacy and identity. The operationalization of Genius Hour from practitioner accounts, digital media and books indicated that the instructional technique may develop identity through its pillars of 'autonomy' and 'purpose' and self-efficacy through its pillar of 'mastery', with this construct supported by the findings of this study. The longitudinal study of the sub-sample revealed that the influences of Genius Hour extended far beyond the allotted classtime and acted as a catalyst for future learning.

REFERENCES

Anderson, C. &. (1988). Teaching for meaningful and self regulated learning of science. In J. Brophy, *Teaching for meaningful understanding and self regulated learning* (pp. 265-309). Greenwich.

Aschbacher, P. L. (2009). Is Science Me? High School Students' Identities, Participation and Aspirations in Science, Engineering and Math. *Journal of Research in Science Teaching*, 564-582.

Blumenfield, P. S. (1991). Motivating Project Based Learning: Sustaining the Doing, Supporting the Learning. *Educational Psychologist*, 369-398.

Brophy, J. (2004). *Motivating students to learn.* New Jersey: Erlbaum.

Buck Institute for Education . (2015). *Project Based Learning*. Retrieved August 15, 2016, from Project Based Learning for Educators: www.bie.org

Colley, K. (2008). Project-based science instruction: a primer: an introduction and learning cycle for implementing project-based science. *The Science Teacher*, 23.

Dewey, J. (1910). *How We Think.* Boston: Heath & Company.

Dweck, C. (2006). *Mindset: The New Psychology of Success.* New York: Pearson.

Elmore, T. (2012). *Artificial Maturity:Helping Kids Meet the Challenge of Becoming Authentic Adults* . New York: Jossey-Bass.

Elmore, T. (2013). *Generation iY: Our Last Chance to Save Our Future.* New York: Associated Press.

Erikson, E. (1969). *Identity, youth and crisis.* New York: WW Norton Company.

Faircloth, B. (2012). "Wearing a mask" vs. connecting identity with learning. *School of Education, University of North Carolina at Greensboro*, 186-195.

Fraunenheim, E. (2006). On the clock, but off on their own: Pet-project programs set to gain wider acceptance; In addition to fueling innovation, policies like Google's '20 percent time' can serve as an important recruiting and retention tool... *Workforce Management*, 40-66.

Grinberg, E. (2014, March 10). *CNN Living*. Retrieved November 22, 2014, from Genius Hour: What Would You Like to Learn Today?: http://www.cnn.com/2014/03/09/living/genius-hour-education-schools/

Guba, E. L. (1994). *Competing Paradigms in Qualitative Research.* Thousand Oaks: Sage.

Gutierrez, K. (2008). Developing a sociocritical literacy in the third space. . *Reading Research Quarterly*, 148-164.

Halloun, I. (1998). Student Views About Science. *Science & Education*, 553-577.

Holt, J. (1989). *Learnng All the Time.* New York: Addison-Wesley.

Howard, J. (2000). Social Psychologies of Identities. In *Annual Review of Social Psychology* (pp. 367-393). Columbia University.

Juliani, A. (2014). *Inquiry and Innovation in the Classroom: Using 20% Time, Genius Hour, and PBL to Drive Student Success.* New York : Routledge.

Kantier, D. (2009). Doing the Project and Learning the Content: Designing Project-Based Science Curricula for Meaningful Understanding. *Wiley InterScience*, 526-551.

Kaplan, A., & Flum, S. (2012). Identity formatin in educational settings: A critical focus for education in the 21st century. *Contemporary Educational Psychology*, 171-175.

Kapur, S. (2009). We Are the Stories We Tell Ourselves. (T. India, Interviewer)

Kesler, C. (2014). *Genius Hour: Where Passions Come to Life*. Retrieved November 22, 2014, from Genius Hour: Where Passions Come to Life: http://www.geniushour.com/

Kessels, U., & Taconis, R. (2012). Alien or Alike? How the Perceived Similarity Between the Typical Science Teacher and a Student's Self-Image Correlates with Choosing Science at School. *Res Sci Education*, 1049-1071.

Klos, M. (2006). Using cultural identity to improve learning. *Educational Forum*, 363-370.

Krebs, D. (2013, January 19). *Dare to Care: Creating, Contributing, Communicating, Connecting, Collaborating, Curating*. Retrieved November 22, 2014, from A Year of Genius Hour : http://mrsdkrebs.edublogs.org/2013/01/19/a-year-of-genius-hour-what-have-i-learned/

Krebs, D., & Kirr, D. (2014). *GeniusHourwiki*. Retrieved December 1, 2014, from Genius Hour Teacher Blogs: http://geniushour.wikispaces.com/

Larmer, J. M. (2010). Seven Essentials for Project-Based Learning. *Educational Leardership*, 34-37.

Lee, C. (2007). *Cultural Literacy and Learning*. New York: Teacher's College Press.

Llewellyn, D. (2007). *Inquire Within: Implementing Inquiry Based Science Standards in Grades 3-8*. New York: Corwin Press.

Maiers, A., & Sanvold, A. (2014). *The Passion Driven Classroom*. Larchmont: Eye on Education.

Marzano, R. (2004). *Classroom Instruction that Works: Research Based Strategies for Increasing Student Achievement*. New York: Pearson.

Mills, A. (2010). *Encyclopedia of case study research*. California: Thousand Oaks.

McLean, K. (2015). *The Oxford Handbook of Identity Development*. New York: Oxford University Press.

Moje, E., Tucker-Raymond, E., Varelas, M., & Pappas, C. (2007). FORUM: Giving oneself over to science- Exploring roles of subjectivities and identities in learning science. *Cultural Science Education* , 593-601.

Moll, L. (1992). *Vygotsky and Education: Instructional Implicaitons and Applications of Sociohistorical Psychology*. Oxford: Cambridge University Press.

National Research Council. (2016). *Next Generation Science Standards*. Retrieved September 1, 2016, from Next Generation Science Standards : www.nextgenscience.org

Oliver, M., & Venville, G. (2011). An Exploratory Case Study of Olympiad Students' Attitudes Towards and Passion for Science. *International Journal of Science Education*, 2295-2332.

Patton, M. (2001). *Qualitative Research and Evaluation Methods*. Thousand Oaks: Sage.

Pink, D. (2011). *Drive: The Surprising Truth About What Motivates Us*. New York: Riverhead Publishing .

Ramirez, A. (2013). Passion Based Learning. In A. Ramirez, *Save our Science* (pp. 22-41). New York: TEDX.

Riedinger, K. (2015). Identity Development of Youth During Participation at an Informal Science Education Camp. *International Journal of Environmental & Science Education*, 453-475.

Robinson, K. (2007, January 6). Do Schools Kill Creativity? (RSA, Interviewer)

Robinson, K. (2010, October 14). Changing Education Paradigms. (RSA, Interviewer)

Roscorla, T. (2013, January 13). *Center for Digital Education.* Retrieved November 23, 2014, from Google's 80/20 Principle Applies to Students: http://www.centerdigitaled.com/news/Googles-8020-Principle-Students.html

Schunk, D. (2012). *Learning Theories: An Educational Perspective*. Greensboro: Pearson.

Tas, M. B. (2010). Perception of Identity in Science Education (POISED): A pilot study of research with secondary school students in England and India. *British Educational Research Association Annual Conference* (pp. 1-4). Warwick: Univeristy of Warwick.

Tseng, K.-H., Chang, C.-C., Lou, S.-j., & Chen, W.-P. (2011). Attitudes towards science, technology, engineering and mathematics (STEM) in a project based learning (PjBL) environment. *International Journal Technology Design Education*, 87-102.

Tucker-Raymond, E., Varelas, M., Pappas, C., Korzh, A., & Wentland, A. (2007). "They probably aren't named Rachel": Young children's scientist identities as emergent multimodal narratives. *Cultural Science Education*, 559-592.

UC Berkeley. (2015). *Science 101*. Retrieved September 22, 2014, from Understanding the Nature of Science.

Ulanoff, L. (2007, February 7). *PC Magazine*. Retrieved November 22, 2014, from Google's 20% Time Drives Innovation: http://www.pcmag.com/article2/0,2817,2340545,00.asp

US Census Bureau. (2000). *US Census Bozeman, MT.* Bozeman: US Census Bureau.

van Eijck, M., & Roth, W. (2008). Authentic science experiences as a vehicle to change students' orientations toward science and scientific career choices: Learning from the path followed by Brad. *Cultural Studies of Science Education*, 611-638.

Vygotsky, L. (1962). *Thought and Language.* New York: Huntington Co.

Wettrick, D. (2014). *Pure Genius.* San Diego: Dave Burgess Consulting, Inc. .

Wiggins, G., & McTighe, J. (2001). *Understanding by Design*. New York: Association for Supervision and Curriculum Development.

Young People's Learning Agency. (2009). *Attitudes to Science: Survey of 14-16 year olds.* London: OpinionPanel.

APPENDICIES

APPENDIX A

GENIUS HOUR PROJECT PAGE

Genius Hour Project

Genius Hour is dedicated class time for students to pursue a project they are personally passionate about. It is based on Google's "20% Time", where one day per week employees are able to work on their own pet projects that will further the company. Genius Hour engages students, and really works on skill development.

Genius Hour Features:

- Students can choose ANY topic that they are passionate about and examine it through a 'scientific lens'
- Students are in the driver's seat- use your own ideas and try to problem solve on your own before immediately asking for help
- Failure IS an option (if you set out to do something and fail, as long as you were dedicated to the process and learned something in the end, you will have actually succeeded)
- Choose a project that is something you don't already know
- Research your project to make a plan of what you will do
- Reflect on your own learning and share it with others
- The project will be done individually, but you may seek feedback from your peers

Examples of Projects:

"The Science of Skateboarding" – a student researched the physics behind various skateboarding moves, and used it to work on his techniques. He documented his progress throughout the project.

"Pennies for Peru" – a student fundraised for an organization dedicated to clean water in Peru and compared the sanitation techniques between Canada and Peru.

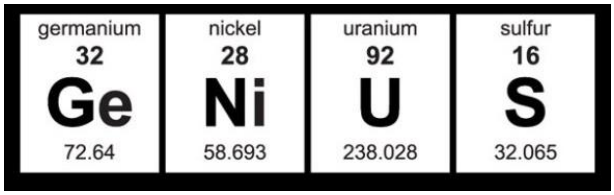
"Wake up in Your Make-Up" – a student looked into the chemistry of makeup and tried to design some that you could wear for days and was still good for your skin.

What will my project look like?

1.) **Paragraphs:** Using at least 2 references (cited in MLA formatting) you will create a short explanation of the science behind your project and a reflection on your learning process (what did you struggle with? What did you enjoy? What would you do differently next time? What questions still remain?). Approx. 2 pages double spaced.

2.) **Project:** you choose what you will investigate and get teacher approval

3.) **Presentation:** you will create a short video (2 mins) that shares your project with your peers- talk about what you did, how you learned and your own personal experience in the project. This can be as simple as a video shot from an i-phone or as complex as using movie editing software.



Assessment:

Date	Item	Assessment
By Oct. 6th	Genius Hour Idea	5 points
Throughout project (each Wed.)	Genius Hour Exit slips- a reflection on what you learned, what your next steps are	10 points each (30 points)
By Oct. 29th	Project & Paragraphs	Paragraphs targets: (30 points) • Connection to science/ science content • Personal reflection about how you learned throughout the project. • Personal reflection- did you meet your own goals?
By Nov 5th	Presentation	30 points

If you have questions, please contact Mr. Bradshaw at the school or Ms. Reuer at marcie.reuer@hotmail.ca

APPENDIX B

LIST OF GENIUS HOUR TOPICS PRODUCED BY STUDENTS IN THIS CASE STUDY

List of Genius Hour Topics

Alternatives to Snow	Ballistics to Measure Density	Shooting Stances & Accuracy
Baking: Mix vs. Homemade	Influence of Piano on Brain Activity	Reading & Gender
Basketball and Spatial Awareness	Lightning & Homemade Tesla Coil	Muscle Memory & Gymnastics
Bowling Throws & Strikes	Ski Climbers	Snow & Avalanches
Building a Robotic Insect		
Cello strings & Sound	How skis are made	Psychology of a Slam Dunk
Chocolate & the Brain	Kicking Field Goals	Writing a Song
Crossovers in Basketball	Running Shoes	Concussions in Soccer
Fly Fishing Fly Tying	Happiness and Random Acts of Kindness	Horror Movie Emotions & Reactions
Food Types & Memory	Running Form- Heel vs. Toe Striker	Mario Riveria's Cutter Pitch
Football Stances & Speed	Ocean Currents	Constructing a Curved Hotel Lobby
Gatorade vs. Water	Combination Instruments: Clute and Flarinette	Riding a Unicycle
How Dry Ice Interacts with Different Liquids	Memorizing Cheerleading Cheers	Learning and Memory
Kicking a Ball	Relationship between music, sports and test scores	BMX tricks
Photography	Anemia & Long Distance Running	Amount of Homework & Grades
Physical Therapy & Dance	Foot Arches and Shoe Selection	Skateboard Designs
Pole Vaulting	Volleyball Vertical Jumps	Nailpolish Remover
Practice on Guitar Playing	Western vs. English saddles	Learning World Languages
RC Helicopters	Colour Guard	Teaching Dogs Tricks
Rube Goldberg Machine	Effect of Music on Mood	Rock Climbing Physics
Ski Wax	Football Gear	Preventing Sports Injuries
Skiing	Fossilization	Violas & Sound
Sleep & Dreams	Soccer	Baking
Swimming	Vacation Effects on Happiness	Coffee
Teen Nutrition	Shooting a Basketball	Physics of Football Tackling
Tennis Racket Strings	Musical Preferences	Catapults
The Perfect Slapshot	Wolves	Word Recognition of Foreign Languages
Vibrations of Guitar Strings	Optical Illusions	Mouse Trap Gun
Wrestling Gear	Dirt Biking	Ballet Shoes & Foot Problems

APPENDIX C

GENIUS HOUR AS DESCRIBED

IN BLOGS AND WIKIS

Name	Grade Level	Traits	Values
Denise Krebs	7,8, K	Self reflective – "practice what I learned.." Life-long learner "radically change ALL of my teaching" Comfortable with Failure: "… right now I am getting my tail whupped"	Passionate learning Collaboration, Creativity, Citizenship Metacognition focus Digital Literacy
Tia Henriksen	VP	Collaborator: "I love the connections we can make with people and expters around the world" Life-long learner: "learning is everywhere around us" Resilient: "not overwhelmed by negativity"	All students can learn Technology Gratitude Personal Autonomy Innovation
Kelley Inden	English 8,9	Reflective: "internal and external battles with assessment"	Inquiry Passion-based Learning Transparency
Valerie Lees	English 10, Humanities 8	Leadership: leading a PD seminar Reflective: "think of your own legacy as a student"	Imagination Creativity Empathy Innovation
Hugh McDonald	Humanities	Appreciative: "I'm a lucky person" Lifelong Learner: "the way I learn and teach has undergone a transformation" "I am passionately curious"	Curiosity Passion
Eric Neumeyer	4/5 Montessori	Inspiring: "try to light the fire in students"	Digital Citizenship Technology
Robyn Thiessen	3	Global Citizen: connects to other schools via Skype and has global projects with her students	Technology Collaboration
Beverley Bunker	French Immersion	Lifelong Learner: "change is amazing and difficult" Experimental Risk Taker: "I am trying new things…" Enthusiasm: "I feel excited…"	Gratitude Work-Life Balance C3 Inquiry- Collaborating, Creativity, Critical Thinking
Chris Kesler	8th grade science	Lifelong Learner: "I would love to hear feedback on how to improve my processes" Risk Taker: "I am terrified, excited and liberated all at the same time"	Passion-based Learning Inquiry
Christine Esposito	Language arts	Open-minded: "expose them to as many ideas as I can" Shared Control with students: "real learning is messy, fun, loud, complicated and sometimes frustrating."	Student Ownership of Learning Student Self Efficacy and Empowerment Collaboration
Craig Dunlap	Computer teacher K-8	Shared control with students: "if you give students some tools and the freedom to work, good things can happen"	Technology Innovation Autonomy
Oliver Schinkten	Not indicated	Adaptable: discusses taking advantage of teachable moments Passionate: "you are the spark plug. Passion and enthusiasm are contagious"	ComPassion based learning Collaboration Inquiry Critical Thinking Ethical Citizenship
Kimberly Hurd	Not indicated	Passionate: "teaching is not a job, it is a passion" Intuitive: "when you touch the heart, you touch the mind"	ComPassion based learning Empathy
Gallit Zvi	Faculty associate-university	Inquisitive: "we need to wonder too" Self Reflective: "I found that looking inward is important" Passionate:	Inquiry Collaboration Passion

APPENDIX D

STUDENT SELF-RATING SURVEY

Initial Rating Scales:

Please rate yourself from 1-10 on the following knowledge, skills and attitudes:
1.) Science is something I enjoy and am passionate about:

NO!!!				Somewhat					YES!!!
1	2	3	4	5	6	7	8	9	10

2.) Science is something I am good at:

NO!!!				Somewhat					YES!!!
1	2	3	4	5	6	7	8	9	10

3.) I see myself as a scientist:

NO!!!				Somewhat					YES!!!
1	2	3	4	5	6	7	8	9	10

3.) Others see me as a scientist:

NO!!!				Somewhat					YES!!!
1	2	3	4	5	6	7	8	9	10

Rate your ability on the following skills from 1-5, 1 being something you really struggle with and 5 being something you excel at:

Science & Engineering Skills	Rating
Asking questions and defining problems	
Developing and using models	
Planning and carrying out investigations	
Analyzing and interpreting data	
Using mathematics	
Constructing explanations and solutions	
Engaging in an argument from evidence	
Obtaining, evaluating and interpreting information	

APPENDIX E

EXIT CARD QUESTIONS AND

UNCATEGORIZED DATA

Exit Cards:
1. What did you learn?
2. How does this project make you feel?
3. What are your next steps?

Administration #1: After first class

1. What did you learn?

Content related comment	105
Presentation skills	3
Writing	3
Misc.	2

2. How does this project make you feel?	
Good	38
Excited	20
fun	8
Okay	6
Interested	5
Project is difficult	5
Like it	3
Excellent	2
Great	2
Happy	2
Ready	1
Enjoyment	1
Going to learn	1
Going well	1
Passionate	1
Awesome	1
Love for it	1
Wonderful	1
Anticipation	1
Fine	1
Not good	1
Strange	1
Challenged	1
Worried	1
Confused	1
Overwhelmed	1
Bored	1

2.) Categorized Data	
Enjoyment (good/ fun/ okay/like it/ excellent/great/ happy/ enjoyment/ passionate/ awesome/ wonderful/ love it/ fine)	67
Anticipatory (excited/ going to learn/ anticipation/ interested)	29
Struggling (confused/ overwhelmed/ worried/ challenged/project is difficult)	9
Other (bored/strange/ not good)	3

Administration #2: After class 3

1. What did you learn?

Content related comment	126
Presentation skills	3
Project Planning	3
Nothing	4

2. Categorized Data	
Enjoyment (good/okay/great/ fun/like it/awesome/ love/ enjoyment/happy)	75
Anticipatory (excited/interested/intrigued/hopeful)	22
Competent (confident/making progress/improving skills/learning/on task/ready/prepared/project will be successful/strong)	29
Struggling (confused/nervous/behind/short on time)	8
Other (bored/not benefitting/unsure/ disappointed/terrible)	6

2. How does this project make you feel?	
Good	43
Okay	13
Excited	11
Confident	10
Great	7
Interested	7
Making progress	7
Fun	6
Confused	4
Improving skills	3
Learning	3
Nervous	3
On task	2
Ready/ prepared	2
Boring	2
Like it	2
Project will be successful	1
Intriguing	1
Strong	1
Hopeful	1
Behind	1
Short on time	1
Awesome	1
Love	1
Not benefitting	1
Unsure	1
Better	1
Disappointed	1
Enjoyment	1
Terrible	1
Happy	1

Administration #3: After class 5

What did you learn?

Content related comment	91
Presentation skills	1
Project Planning	1
Nothing	3

How does this project make you feel?

Good	38
Confident	7
Excited	6
Great	6
Like it	5
Love it	5
Fun	4
Need to do more outside of school	4
Making progress	3
Nervous	3
Okay	2
Interested	2
Enjoyment	2
Worried	2
Going well	2
Don't want to do it	2
Positive	1
Awesome	1
Unnecessary	1
Comfortable	1
Hard to search things	1
Cool	1
Organized	1
Caught up	1
Intrigued	1
Not good	1
Learning	1
Need more time	1
Unsure	1

2.) Categorized Data	
Enjoyment (good/great/like it/ love it/fun/okay/enjoyment/awesome/cool)	64
Anticipatory (excited/interested/intrigued/hopeful/need to do more work outside of school)	14
Competent (confident/making progress/going well/comfortable/organized/caught up/learning)	16
Struggling (nervous/worried/hard to search things/need more time)	6
Other (unnecessary/not good/unsure)	3

APPENDIX F

SUB-SAMPLE, INDIVIDUAL INTERVIEWS

Q.1 What features of Genius Hour are relevant to student identity and self-efficacy								
Topic of personal interest, a large personal investment in terms of time and effort, got to showcase personality and interests (strong desire to make something of good quality for peers)								
(I) Describe your level of personal investment in Genius Hour vs. other tasks in school.	It was kind of different than other projects- this one I put more work into than others one, since it was something I liked I put more work into.	I put a lot of time into it – maybe 50% more time than normal projects.	Worked harder on this than on some other things, a little more personal – get to research what you want don't have a set thing	GH I spent a lot of time outside of school working on GH. I had my main research during class and then I applied it to experimentation and video production where other school projects the bulk is done at school and do a little at home, GH allowed me to branch out	Yes it was so open that you could choose absolutely anything you wanted to do- there was no rules so you could do anything that described you as a person or influenced your life beforehand- it also made it fun to do – I didn't have to talk myself into doing it- it came more naturally	I worked really hard on it especially since I was interested in it. I wished I had the book with me to pull out quotes from the book. It was a big project and I had to put a lot of work in and I would put the same amount of work into any other big project. I really liked it.	Very invested- it was something I was super interested in.	I felt like it wasn't on the bottom, not quite on the top- when you had free time- more enjoyable to do than other work, I would study more about GH than other Homework because I was more interested in it.
(I) What are your thoughts on sharing Genius Hour with your peers? Was it hard to do? How was it different than other presentations you have given?	It was different because you get to show your interests – it is something you are knowledgeable about already- it is easier to share because you already know a lot about the subject. Confident to show your personality.	It was the biggest presentation I have done in a while so it had to prepare with the video and I retook it a number of times because I wanted it to be good	It wasn't hard- I kind of risk it- I don't care what they think- if they think I am weird- I go for it and wing it..	Actually I have done a couple of projects where I share a video with the class- it was not difficult for me personally, but if you hadn't done a video before it would not have been too difficult- peers here are really comforting. For this presentation there were a lot of different options you could present with and with other school project it is usually limited – so many different options.	It was hard to do because I was singing and singing is kind of far out there it is not something you normally do or normally here- I also liked it because it wasn't live- it was a video and there was not as much pressure- it was nerve wracking listening to myself, but it was alright because I had listened to it over and over and I became confident with how it sounded.	It was different because I have only done a few other science presentations – it was fun sharing it with everyone because I could see their faces and it looked like they were interested.	It was fun= I could show my personality.	I felt like it was different than what I am used to- having to present a PowerPoint in a formal aspect- this was more enjoyable, sit in the comfort of your home to present to others and talking about it with others, after friends see the video the students wished they could do similar presentations and free work and choose their topic and elaborate off of it.
Q.2 How do the features of Genius Hour develop student science identity?								
Self determination- students got to make many choices regarding the topic of study, the approach and the presentation style, got to showcase many talents, skills and interests in one spot, project required persistence and hard work, social interaction with peers, parents and teacher, encouraged self reflection on personal passions and the world around them, pride in the video artifact, having to navigate the research process independently, personable teacher with positive student interactions -need teachers to be open, kind, encouraging, leading by example								
(L) List the traits, skills, attitudes that you feel make a good scientist? Circle the traits developed by Genius Hour (I) How did Genius Hour develop these traits?	*Positive,* likes science, *enthusiastic, *smart, doesn't give up, observant, learns from mistakes, *Interested, *focused, *open to change, *able to express/ share ideas with other people and improve by using others' criticism GH helps because I could find out what I wanted to do and use all of the skills and put them all in one project together and each of them built on each other- I was positive about the project so it helped me understand the science	A good scientist should want to *research what they are studying. It shouldn't be forced. They should be *excited to study it. Got to choose what you studied and you also got to choose how to present the study.	They need to know more, want to learn, take rests*, work hard* and dedicate time* Dedicating time to work and research and stuff and had to do a little out of school- if you just slacked you wouldn't get it done, taking risks- just did and try your best…	Curiosity*, Passion*, perseverance, creativity*, dedication GH brought it all together in one spot. All the traits, my interests….	Curiosity*, intelligence*, determination*, hope, faith, strength* For curiosity- I had a lot of questions about guitar and I found out a lot that I didn't know Intelligence: it made me I had to think about how to conduct the experiment 0 it was difficult with the guitar- didn't know where to come from had to think really hard about how I wanted the experiment to go Determination- and perseverance- I messed up so many times and I had	Hardworking*, passions*, persistence*, intelligence*, positivity* Just because if something went wrong you had to keep going through it and be positive. I had to do 3 different jings because 2 didn't work, you need to keep trying- if you aren't passionate you won't' keep trying and wont' keep going, increased my intelligence- I found out a way to improve my memory	Hardworking*, Social*, persistent*, firm in what they think is right*, love for solving problems, *love of science GH helped with hardworking and persistent part by making me actually do the work and doing all the research for it and everything. The social part by going and asking people about bball people that are good at it. The love of science is the study of everything- question everything – trying to solve the problems I think that is pretty cool.	Ability to work through problems, ability to work hard*, have interests in what is being studied*, ability to work with others*, pride in what you do* It gave you the ability to work hard you had to focus on your deadlines you had to manage your time by how you thought it should be done gave you the ability to focus on the things you enjoy studying- you were allowed to do anything you enjoyed and look at it through scientific glasses

	more and enjoy it more. Helped me learn some things about physics. Learned how to get other people's ideas and criticisms about the project- I had to tweak it a lot- there were a lot of suggestions my parents had for it- the first video was not the same as the final project- that is for sure.				to start the video tape over, I played a wrong chord and played a wrong note. And patience… Strength- I don't know if I could have shared my voice in front of everyone if I wasn't strong enough to take the criticism- everyone judges no matter what - confidence			…. working with others talking with teachers and others to get info you needed pride in what you do – gave you the stronger connection to what you were learning by doing something you enjoy instead of taking someone else's idea and having to elaborate off of it.
(I) What personality traits or interests of yours are evident in Genius Hour? How did Genius Hour help develop these traits?	Unicycling- the topic Likes drawing- drawing on white board Creativity- Making videos- into technology- Likes science- always likes projects that I've done in science Helped me show the traits and use them altogether in one single project. Areas improved from doing the genius hour project. They helped each other out- used them together to do the project- and to figure out how to incorporate all of them.	Always liked dinosaurs, art drawings, got sister to voice the triceratops Gave me a chance to make a diorama which I always wanted to do, let me play around with the stop motion thing.	Curiosity, exciting, funny- sense of humour, loves movies- wants to be a director, know more knowledge Showed how you can finish something – like work hard at something and make it look good and develop my skills a little bit	Felt like perseverance was key because you had to dedicate all of this time to the project Curiosity is always really helpful Likes winter sports Having a dedication in whatever you are doing is important to excelling in that area They forced (revised to encouraged) me to bring out those traits because you are encouraged by your teachers and also your peers to do really well in GH	It was my musical side and creative side	Read about it in English- made me think about how I could make my memory better, and then it talks about it in the book we read that it is more about a pleasure thing- it is not something you would want to do on a daily basis because it is so time consuming. I like to remember everything- I am a perfectionist in that way so sometimes it is hard to remember so if you give yourself the memory palace or pneumonic devices it will be easier Made me think about something I wanted to become better at and by doing that I did improve my better. Don't use the memory palace because it takes a while to come up with the memory palace. If I really wanted to I could improve my memory.	I am more outgoing and that helped, kind of hard working and persistent, interested in basketball, With basketball since I wasn't good at it helped me get better at it and with being outgoing and being persistent- it helped with that too.	Guitar and music, the ability to teach about music I think it made me think about something that I loved a little stronger than before. Before I thought about it as playing an instrument- actually learning the science behind it helped improve techniques- focus on pressure and picking styles
(I) Do you see yourself as a scientist? Did Genius Hour influence how you see yourself?	I did see myself- I really like science. Yeah it helped with figuring out how to put a whole project together and communicate it to people.	I do. In a way- it kind of let me research the topic a bit more	I guess- depends on what kind of science- I would align myself with physics - more curious and can work really hard if I really try	I think everyone is a scientist in the sense that they can look at something and be curious about it and research. GH brought out some things in me that I didn't know where there before- I didn't know I had all this dedication for technology and GH helped me discovered it.	Yeah – it made me realize that science is all around us and just by thinking or discovering as simple as for instance making a new type of drink- that's science, everything around us is science	Maybe. It would be fun to be some sort of doctor. I don't know if I would want to be a scientist but maybe something that has to do with medicine. Yeah – a lot of people don't have the best memory, it made me rethink about how I can improve my memory.	Yes. In the future. It helped me see myself in a better way see myself as helps me with my future.	In certain ways – maybe not as a textbook definition – interest in want to learn more and the things I am interested in could qualify me as a scientist. I felt like it sort of showed me how I like to do things want to elaborate more on my ideas instead of working with others and compromising, got to do it my way , play my guitar

								and enjoy it and show others what I do
(I) What can teachers do to help students see themselves as scientists? What traits should they have?	I like the idea of choosing own topic and something that was of interest to us. Instead of sitting down and taking notes- it helps to visually see things or do things that show science. need to be relaxed and open minded.	Encourage free choice studies give more time in class – few days extra….	Do a lot of labs and give them ideas to research- field their own interests open and gets personal, but not really personal, tries to get you going…	Teachers can give their students words of encouragement and let them know they have the capability to be passionate about an experiment and have the creativity and perseverance to into their work. encouraging, a nice pillow to fall back on – comforting and sympathetic and overall a kind person.	Well they can encourage students- that is a very big one, push students but also give them a hand to lean on so they don't feel alone through it, complimenting them and boosting them up because it is hard to do something you aren't confident in- Mr. Bradshaw encouraged everyone and said it was okay to mess up because that is what happens in life drive- if the teacher is driven, passion for what they are doing if they seem to like it and love it and invest their lives in it- try what they are trying, kindness is very big then the students can feel secure in what they are doing and the teacher needs to be intelligent and know what they are talking about to give the students confidence, understanding- if a teacher is understanding it takes the pressure off the kids – if there is not as much pressure it improves how we learn and how we do everything in science class.	What can teachers do to help students see themselves as scientists? Encourage them and if they are not into it, try to show them some aspect of science that has to do what they are interested in. If they are interested in it science will be more interesting to them. be open to new ideas because if someone wants to do an experiment on something they are really interested in, encouraging, helping them to enjoy science.	Teachers can love what they do. Encouraging and kind are the big ones	Giving the ability to learn about things that they would enjoy and showing them that science is used in many ways they may not consider- shooting a bball to the science behind why cars run… making it fun- find different activities that students have group conversations about about why they think certain things work and then why they do work- create the creativity—it's about what happens and what we think may happen- never been before a fun teacher a teacher that is willing to not tell you know but adjust your ideas to something that is more suitable to you to give them better chances for success, being kind and understanding of the students, learning about the students, being a friend more than a teacher, someone they can trust.
Q.3 How does Genius Hour develop student science efficacy?								
Starting from a point of interest, strength- build on this foundation, required dedication and patience, time management, positive feedback from peers, teachers and community was encouraging, improvement was tangible, pride in the final product and self reflection on further improvements, a change in how science is perceived, the process of the project was valued								
(I) What were the keys to your success in Genius Hour?	I think I definitely showed something that I liked- one of my interests that helped me better understand what I was doing- it helped me figure out if I fell down, why I fell down.	Picked something I wanted to study, I was excited about it and that made me want to put time into it	Dedicating time at home to edit trying to make it as good as you can	Dedication and a passion for what I was doing were the main keys- I really like winter sports and avalanches are very common where I live- I had basic knowledge and it brought out my passion and curiosity	Definitely patience- definitely just trying new things that I hadn't done with the guitar before and stepping out of my comfort zone	Jing was really cool because you could talk and still have the photos and the interaction with the rest of the class was really fun to see if they could remember the memory palace. High investment- if you aren't interested it won't' be as successful	Doing something I loved. Yeah that was it	I think time management- not to put things off too late, when you don't get your paragraph done in time was what caused some stress

(I) Were you proud of your work? Why or Why Not?	Yes- there are a few things I would have changed. I put a lot of effort into it- it took me awhile to get the footage and do all of the editing.	I thought it was kind of dumb and then everyone kind of liked it and that made me feel good about it.	I was- it was one my first really good videos- I have made them before but this one was really good	I was pretty proud of my work- I spent a lot of time doing GH I developed a video that was really well rounded- experiment with research and voice overs	Yes I sure was because through this I could see my improvement and it was interesting to see where I started from and where I got it- seeing that improvement made me really proud.	Yeah I was- I would have been more proud, my voice sounded muffled on the speaker so next time I would try to enunciate a little better if I were to do it again	Definitely proud of my work. Proud of the actual success I wasn't expecting to do that good.	I was proud of my work because I worked hard on it and I was able to show what I do, how I do it and why I enjoy it and show the science behind it. Helps you enjoy what you do a bit more, you learn the history, who to look up to, without those people before you that created it and changed it wouldn't be the same as it is today
(I)How did Genius Hour influence your confidence in science?	It made me feel better because I was proud of seeing it as a final project and then looking back at the whole process of making it- it was good to see it came out into one good thing. Had it not turned out well- still would have benefitted- not as satisfying The more work you put into something the more you get out of it	I guess it made me more confident in front of a camera even though I didn't show myself on it.	Boosted my confidence a bit- science is a lot of research and dedicating time	After I presented the video to the class my peers and teachers congratulated me and it boosted my self-esteem and my parents thought my work was really nice and it made me believe I am a scientist and I am capable of these things	It influenced it and made it better- I realized not all science is super complicated or hard to understand- science is everywhere in everyday life, we do it accidently- made me more confident in that way	Because it does work with the scientific method- you come up with what you are going to research- apply your prior knowledge, I did have some sort of procedure, it was more what I did in my presentation –if people's memory could improve using the memory palace and in the end I had a conclusion. Science is trustworthy. Every time you step in front of the class it improves your confidence because you are working on your performance in front of everyone else. if I wasn't confident it wouldn't have been as good as a presentation.	Made me more confident- I could see myself as a scientist in the future	It showed me there is more to science than sitting in a lab and staring at slides or understanding the body and diseases, the broader aspect of what science is and being able to incorporate the small things in science to learn and understand what you do and understand the physics behind it.

APPENDIX G

SAMPLE OF SUBSTANTIVE COMMENTS

FROM WHOLE CLASS DISCUSSION

Starting points for discussion: What did you like or enjoy? What would you change? How is this project different than your regular school experience?

Asher: the great thing about genius hour was the **unrestricted freedom** to choose whatever [topic] you wanted. **Broad topics that engaged the body and mind**.
Gavin: I enjoyed the project and think it's a great concept and it should have lasted longer. I regret my topic choice, but I liked that it **encourages further researching** than just what's in the text. I think we should start a genius hour club and I just have one question- **can we do this again**?
Meriel: **At the beginning I wanted more organization**- like a specific sequence of steps to do
Sage: I liked I got to **indulge an interest while learning instead of regurgitating**
Tony: I found it **tedius,** you [teachers] were always bugging me- 'gotta do this, gotta do that' [the steps in the project]
Caroline: I **liked being able to watch the videos** [of student projects] and I wished there would have been more time
Wesley: **In a normal class you have to be like a sponge- sop up the info in the fashion they [teachers] ask you to and wring it out, while with this [Genius Hour] you actually get to create something**
Jaden: I need **more due dates and guidelines**
Nathan: It gave you an **opportunity to learn about something you are interested in**. I would have gotten rid of the video and just done a paper.
Sarah: I liked that we got **to pick our own topics** we wanted to learn about…. It was **hard in the beginning to focus on a topic**
Hazan- I liked that there was no specific topic and **we got to go our own way,** with no rubric I decided what was important… I didn't like the paper, but liked the video
Annie: I **liked being able to do a project independently**, it was **wide open** and everyone was really **flexible**
Sadie: it was **fun** for me. I wanted more time in class than just Wednesdays
Grace: I liked **picking my own project** that I wouldn't get to learn about otherwise
Briley: **intermediate due dates** would have helped me
Shane: Genius Hour is more **off on your own- like going down many different streets** while in school everyone must follow one path. Different from regular homework- I **liked the variety**.
Jaiden: there were **some parts that were really stressful** – I am bad at deciding
Olivia: it was **fun to do something new**
Katie: I liked getting to **dig deeper into my interests**
Augusta: I **liked the individuality of the projects**, but I wish Genius Hour was at a different time of the year
Ellie: I **liked picking a topic**, but didn't like the video- I am not good with technology
Gabby: I liked that I **got to use my passion**, but also did not like the technology
Alanna: I **wanted there to be more presentation types**
Hunter: I really enjoyed our time to do whatever we wanted and that **things were not 100% guided**. **The beginning was hard, at the time I felt like I wanted more direction, but in the end I liked that I got to choose**
Amy: I **loved the freedom**, but wanted **more class time**
Tegan: I wanted more time or even just a **longer due date**
Joel: I liked that **class time was for asking questions instead of just listening**

APPENDIX H

SAMPLE OF SMALL GROUP INTERVIEW QUESTIONS

Sub-Sample, Small Group Interview Question Sample

1. Did Genius Hour change the way you see science? The way you see yourself?
2. What was most meaningful to you about the project?
3. What skills do you think you developed as a result of doing Genius Hour? How did you grow? How have these skills carried forward to other areas?
4. How have these skills carried forward to other areas?
5. How was Genius Hour different than your typical assignments in high school?
6. Did you make any realizations about Science and your ability to do science during the Genius Hour process?
7. What were you the most proud of?
8. What aspect did you find the most challenging?
9. Did Genius Hour influence your career path in any way?
10. How has GH affected you in the long term?
11. If you could summarize "the Genius Hour Effect", what would you say?
12. Go back in time and give yourself advice at the beginning of your Genius Hour project.
13. Characteristics of people that did not respond to Genius Hour
14. How are these periodic meetings influencing you?
15. Do you think Genius Hour is worth the time investment?
16. Describe your post-secondary plans
17. How was Genius Hour different than your typical assignments in high school?

APPENDIX I

STUDENT PROJECT EXEMPLARS

Sudent Project Examples

"Leon" (the science of the guitar): https://www.instagram.com/p/BOulArNgDo1/?taken-by=common_music

"Ava" (the science of snow): http://m.youtube.com/watch?v=1uXSASO2Edo

"Kay" (claymation of fossilization)

APPENDIX J

INSTITUTIONAL REVIEW BOARD APPROVAL

MONTANA STATE UNIVERSITY

INSTITUTIONAL REVIEW BOARD
For the Protection of Human Subjects
FWA 00000165

[illegible]
Chair Mark Quinn
406-994-6783

MEMORANDUM

TO: Marcia Rauer and Michael Brody

FROM: Mark Quinn
Chair, Institutional Review Board for the Protection of Human Subjects

DATE: October 13, 2014

SUBJECT: *How Will Genius Hour Impact Student Attitudes towards Science and Self-perception of Their Ability to Perform Science Tasks?* [IRB1013141]

The above proposal was reviewed by expedited review by the Institutional Review Board. This proposal is now approved for a period of one year.

Please keep track of the number of subjects who participate in the study and of any unexpected or adverse consequences of the research. If there are any adverse consequences, please report them to the committee as soon as possible. If there are serious adverse consequences, please suspend the research until the situation has been reviewed by the Institutional Review Board.

Any changes in the human subjects' aspects of the research should be approved by the committee before they are implemented.

It is the investigator's responsibility to inform subjects about the risks and benefits of the research. Although the subject's signing of the consent form documents this process, you, as the investigator should be sure that the subject understands it. Please remember that subjects should receive a copy of the consent form and that you should keep a signed copy for your records.

In one year, you will be sent a questionnaire asking for information about the progress of the research. The information that you provide will be used to determine whether the committee will give continuing approval for another year. If the research is still in progress in 3 years, a complete new application will be required.