A SOCIOCULTURAL STUDY OF MATHEMATICAL AND OTHER IDENTITIES OF 'STRUGGLING' TEENAGE BOYS

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I certify that all material in this thesis which is not my own work has been identified and that no material has previously been submitted and approved for the award of a degree by this or any other University.

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Abstract

The purpose of this study is to gather and describe case studies of 'struggling' teenage boys, focusing on their identities, which are mediated by the discursive practices associated with school mathematics and other activities. The sociocultural model of identity unites an individual's psychodynamic continuity with the roles and positions that emerge from his/her social interactions. The setting for the investigation is a small single-sex, non-traditional secondary school, in which the sample is seven boys, ages sixteen to eighteen, who have lost interest in the academic mainstream. Qualitative data were collected on individual boys, and then matched in a table to the theoretical framework. The study raised five issues about identity, struggling teenage boys, and school mathematics. To negotiate the dialectic of opposing identity norms, struggling teenage boys employed identities as expressive tools that held desirable positions for them in school mathematics. In the organization of multiple identities, salience depended upon the intrinsic and extrinsic gratification associated with knowledge of mathematics. Positive mathematical identities clustered with compatible social identities that were also supported by these rewards. The sociohistorical availability of identities increased in nontraditional mathematics courses that provided the boys with opportunities to enact positive roles. Many of the boys communicated positive attitudes towards school mathematics in relation to their future career goals. Though they may have struggled, they expected to achieve conventional success in the adult world. The issue of identity and emotions was illustrated by the shame and mistrust that accompanied the loss of a former identity such as a "gifted" level in school mathematics. For some struggling teenage boys, mistrustfulness was evident in their discussions about money. They expressed an affinity for simple arithmetic, which they

could easily master with repetitive practice. Implications for teaching include cultivating future-oriented identities, incorporating ‘money’ themes, and offering customized courses.

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CHAPTER 1

INTRODUCTION

Research Focus

The purpose of my study is to gather and describe case studies of 'struggling' teenage boys, focusing on their identities, which I assume are mediated by the discursive practices associated with school mathematics and other activities. Identity is defined as a "typified self at a stage in the life course situated in the context of organized social relationships" (Weigert et al, 1990, p. 53). This definition of identity has both psychological and sociological roots, uniting an individual's psychodynamic continuity with the roles and positions that emerge from his/her social interactions. The term 'sociocultural' embeds action, or how we do things, in the milieu in which it is carried out (Wertsch, 1991). Actions and interactions, and the shaping of personal histories, are dependent upon society and culture, the civilization created by people, at a particular time.

A sociocultural approach to identity assumes that identity is (1) dynamic and developing, (2) negotiated in the dialectical relationship between individual and social context, and (3) mediated by discursive practices (Vadeboncoeur & Portes, 2002). Discursive practices refer to activities such as mathematics, described by Wittgenstein (2001) as "language games" that derive their meaning from "forms of life," or how we live. Semiotically, we act out many different language systems and signifying practices, including talk, gestures, and written symbols, to communicate with one another. In my sociocultural study of identity, the unit of analysis or the elemental partition that mirrors the entire entity under study is 'mediated action,' which is inextricably bound to the agent, who is the 'person(s)-acting-with-mediational-means' (Wertsch, 1991). If, as Sartre said, "Doing is being," then ways of

doing vary, depending upon who one wishes to be (Lofland, 1976). Semiotic mediation of identity is employed by individuals to communicate who they are, suggesting that identities are social and cultural inventions (Holland & Lachicotte, 2007).

Presupposing that 'identity' is a cultural production of a flesh and blood human being, my research utilizes an eclectic model of sociocultural identity that synthesizes the work of Eric Erikson, George Herbert Mead and Lev Vygotsky (Holland & Lachicotte, 2007). (What follows is a condensed account, since I develop these ideas more fully in Chapter 2, Literature Review.) In the sociocultural form, individuals have a single Eriksonian identity, which represents the psychological consistency one experiences by living a social life. On the other hand, an individual may possess many Meadian identities or 'practised identities,' as they are associated with diverse cultural activities such as doing mathematics, participating in athletic sports, or creating a social networking profile on the Internet. Meadian identities are used to compare the actions of individuals and the choices that they make as they move from one practice to another in a social context that extends to the virtual world. An individual may possess multiple, fragmented selves constructed through engagement in a variety of interpersonal communications specific to a community of practice. However, the presence of an Ericksonian identity insures that each individual's mental existence is coherent (i.e., biologically, an individual has one brain and one life span). In this respect, the sociocultural framework circumvents the problem of 'multiphrenia' or the splintered identities associated with postmodernism and the rise of communication technologies, articulated in the work of theorists such as Gergen (2000), in which an individual's core 'identity' is a 'pastiche' of endless cultural appropriations, or 'relational,' where relationships eclipse the individual self. In the sociocultural model of

identity, Vygotskian developmental concepts emphasize how semiotic mediation allows an individual to exert control or agency, whilst his/her identities serve as organizers and place holders for desired social positions.

School Mathematics

Continuing to define the key terms used in my study, the word 'mathematics,' as distinguished from 'school mathematics,' refers to the practices surrounding the use of axioms, a formal system of symbols, and the rules for manipulating those symbols. The emphasis is on the process or rules of transformation, which are clearly separate from the symbols employed (Shaffer & Kaput, 1999). A well ordered sign system, mathematics is learned conversationally within a community of practice, in a semiotic triangle having vertices of student, teacher, and text (Ernest, 1998). Mathematics also concerns problem solving where problems may be posed with figures and ordinary verbal communication. I assume that a learner's mathematical identity is formed over time through engagement in conversations (understood broadly to include textual productions and exchanges with teachers and others) that immerse him/her in the specialized discourse of mathematics. Mirroring the learner's experiences carrying out mathematical tasks, identity as self-as-learner of mathematics could embody "success and positive attitudes or perceived failure and negative attitudes" (Ernest, 2004, p. 77).

Becoming proficient at mathematics is a desirable choice in many respects, one being that a learner's mathematical prowess enhances the options of career he/she may pursue or aspire to pursue in the future. The personal desire to realize a professional identity is sometimes an extrinsic motivation to learn mathematics. Mastering the language of mathematics

allows membership in an international community that may open doors in the world of work, as evidenced by the notion of math as a 'critical filter' for elite professions like engineering and medicine (Sells, 1973). Walkerdine (1990) found that one reward for learning mathematics was a feeling of mastery and competence, which equates to social power. Nevertheless, often, the status placed in mathematics education on precocity and acceleration, a scenario in which efficiency and speed are cultivated over depth and insight, is likely to cause difficulties for some learners (Thurston, 1990).

My own attitude towards school mathematics, socially constructed nonetheless, is that it is an enjoyable language to learn for reasons that I choose to illustrate with Deleuze and Guattari's (2007) useful metaphor of the tracing and the map. A 'tracing' is like a tree because it grows by reproducing the same pattern in it branches and leaves. On the other hand, a 'map' is in a constant state of flux; a map "is open and connectable in all its dimensions; it is detachable, reversible, susceptible to constant modification" (Deleuze & Guattari, 2007, p. 12). Whilst tracings represent structures that get reproduced by repetition like a genetic code, maps are rhizomes that increase their power by increasing their connections. According to Deleuze and Guattari (2007), mathematics resists tracing: Like a map, it is open-ended and teeming with connections. Gracefully put, the learner of school mathematics is immersed in an expansive language, which unfolds like a map beckoning towards new territories. Though it is true that every human language, mathematics included, is invented by people and is meaningless without the company of some lived activity, the experience of exploring the 'map' is, to me, an aesthetic state of 'becoming.'

If only describing my pleasure in doing math for math's sake, my case illustrates how positive experiences with mathematics encouraged me to construct a positive mathematical identity. Wenger (2006) argues that learning, in general, has identity-transforming effects:

> Learning transforms our identities: it transforms our ability to participate in the world by changing all at once who we are, our practices, and our communities. (p. 227)

Participation as meaningful engagement, practice as deliberate performance, and communities as opportunities to build relationships with people, form a tripartite structure for learning. Starting this learning process often depends upon the actions of a teacher, who must forge a connection to the learner with "a frail bridge across the abyss, a slight breach of the law, a small gift of undeserved trust," and many other deliberate acts of kindness (Wenger, 2006, p. 277). I believe that nurturing a learning apprenticeship with a 'struggling' student typically requires extraordinary means.

Research Questions

Focusing on 'struggling' teenage boys who have lost interest in the academic mainstream, the setting for my investigation is a small single-sex, *non-traditional* secondary school, where I am employed as a mathematics teacher, and as an assistant headmaster. The school is non-traditional for its small and nurturing residential milieu. My nine years of direct participation with 'struggling' students affords me with what Lofland (1976) refers to as "intimate familiarity." Utilizing an opportunity sample of individuals, my study asks "how" rather than "why" questions of boys doing mathematics and other social activities (Lofland, 1976). My research questions follow, with brief explanations, reflecting the sociocultural approach to identity:

1. *How does doing school mathematics mediate the identities of 'struggling' teenage boys?*

   The ways in which 'struggling' teenage boys do school mathematics, including participation and avoidance, may arbitrate their mathematical identities.

2. *How do 'struggling' teenage boys mediate their identities in school mathematics?*

   The ways that 'struggling' teenage boys communicate their mathematical identities reflect possible characteristics of doing school mathematics in a particular setting, for example: rigour, competition, acceleration, and carrying out abstract practices.

3. *How do 'struggling' teenage boys mediate their identities in school mathematics and their identities shaped by other social practices?*

   Ways of doing school mathematics may differ, or not differ, from ways of doing other activities such as athletic sports, suggesting an agreement/disagreement between various social identities, marking compatible/incompatible social roles/positions.

4. *How do the boys' past experiences mediate their present identities in school mathematics?*

   This assumes that a boy's "past is present" as he appears to act on the basis of former experiences (Rogoff, 2002, p. 155).

Research Subjects

Many of the boys have an emotional or behavioural diagnosis, such as Attention Deficit Hyperactivity Disorder (ADHD), Oppositional Defiance Disorder (ODD), and/or learning disabilities (LD). These labels, combined with the boys' troublesome actions at home and at school, justified customized placements in both the public and private sectors. Rising to

the task of providing special services, in the United States relatively new, private-pay wilderness programs and therapeutic boarding schools provide interventions for 'struggling' youth, who, because of the familial-financial obligations involved, are largely middle to upper-middle class, white teenagers (Behrens & Satterfield, 2006). Parents often hire private educational consultants to help them navigate the many therapeutic and/or educational choices. Each milieu provides different therapeutic modalities, such as wilderness programs utilizing the outdoors, and therapeutic boarding schools offering emotional and behavioural support in structured academic environments. Since they are short-term placements, it is not unusual for students in this venue to attend multiple schools and programs, creating a unique set of challenges surrounding their intermittent academic studies.

What attracts me to the sociocultural view is that it de-emphasizes personal properties such as ADHD, ODD, and LD, focusing instead on individual actions and mediated identities within a community of practice. In a therapeutic-based field dominated by behaviourist and cognitive themes concerned with quantifiable behaviour and internal mental processes, this is, to me, an exciting alternative. My motivation is to erect a theoretical framework that I can use to document and inform my work at my school and in similar situations at other institutions. Given that there are few sociocultural studies that have been conducted in this new sector of education, it is possible that my effort will appeal to a wider audience within the larger educational community.

An Emphasis on Identity

To sum up, my research utilizes a sociocultural model of identity to gather and explore case studies of 'struggling' teenage boys doing mathematics and other social activities. In this chapter, sociocultural identity is explained as a synthesis of the work of Erikson, Mead, and Vygotsky, which provides a theoretical basis that I analyze in greater depth in Chapter 2, Literature Review (Holland & Lachicotte, 2007). My fundamental unit of analysis here is mediated action, which is bound to the agent, who is the 'person-acting-with-mediational means' (Wertsch, 1991). In carrying out my research, I focus on "how" rather than "why" questions (Lofland, 1976). My motivation is to construct a sociocultural framework to document my research subjects' identities, both in and out of the mathematics classroom, thereby providing me with a rationalization to explore the relevant *identity literature* and current *empirical research*. In the next chapter, I first present a range of thinking on identity, since sociocultural perspectives owe a debt to previous traditions. I bring in the literature pertaining to mathematics education *after* this in-depth discussion of identity.

CHAPTER 2

LITERATURE REVIEW

Introduction

This chapter presents a review of relevant literature in two parts. Part I provides theoretical background that supports the conceptualization of my research by addressing the three components of the sociocultural identity model, Eriksonian identity, Meadian identities, and Vygotskian developmental concepts (Holland & Lachicotte, 2007). *Eriksonian identity* is discussed in Part I sections entitled ***'Ego' and 'Edo Identity'*** and ***Emotional Subjectivity***, beginning with an analysis of key psychoanalytic terms aimed at discussing psychodynamic consistency over the life course. I also offer a brief note regarding emotional subjectivity. *Meadian identities* are developed in the sections entitled ***The Reflexive Process*** and ***Social Interaction*** that explain the reflexive process, social interaction, social roles, and the salience of identities. The section called ***Identity*** presents a comprehensive definition of identity to summarize the essential points. Finally, *Vygotskian developmental concepts* are the subject of the section entitled ***Developmental Concepts***. I set up the sociocultural framework by combining the social perspective of identity with Vygotskian developmental concepts relating to the semiotic mediation of identity. I conclude this analysis with the sociocultural view of identity as a mediational means. Part II focuses on school mathematics and presents empirical research with results for comparison. It also provides additional theoretical details concerning a sociocultural view of learning mathematics, learning and identity, and struggling learners.

Part I: Theoretical Background

'Ego' and 'Ego Identity'

The *Eriksonian identity* in my sociocultural model is what Erik Erikson (1980) referred to as 'ego identity,' which this section defines. Erikson's (1980) view of *psychodynamic consistency* was influenced by the psychoanalytic theory of Sigmund Freud (1995), whose original "*Project*" attempted to model human psychology with an electro-mechanical system, governed by the laws of classical physics. Fusing the psychological and the neurological, the mind or centre of mental life may arise through biological processes that are linked to the human nervous system, a network of sensors in which the brain is the control centre. Mental life, also known as the 'psyche,' is divided between psychic activity of which we are aware and the psychic material of which we are unaware. Freud conceptualized "the person as an intact, closed system" with "little provision for the psyche's influence by others in an intersubjective, social world" (Hoare, 2005, p. 22). Freud (1991, 1994, 1995, 2005) offered a plethora of technical terminology to facilitate his complex analysis of our inner life, yet presented minimal discussion concerning the outer, social component of our existence, an issue that was later addressed by Erikson (1980, 1993, 1994).

In his paper, *The Unconscious*, Freud (2005) theorized that the psyche was a landscape composed of three topological fields: the conscious (*cs*), the preconscious (*pcs*), and the unconscious (*ucs*). The conscious region contains the psychic material accessible to us, whilst the other two realms, the preconscious and the unconscious, contain dormant psychic material, which is either latent or repressed. Latent material has the capacity to surface in the conscious, whereas the act of repression, or blocking from consciousness, can confine psychic material to the unconscious. An individual processes a continuous stream of external and internal stimuli, known as 'perceptions' (Freud, 2005). Perceptions leave

footprints upon both realms in a continuous ‘dance’ between the conscious and the unconscious.

Freud (2005) described the primal-evolutionary and early-childhood memory content of the unconscious (*ucs)* as the “native population in the psyche:”

> If human beings do inherit psychic formations, something analogous to animal instinct, then these are what form the core of the *ucs*. Everything that is discarded over the course of infantile development – material not necessarily different in nature from what is inherited – is then subsequently added to this core. (p. 77)

The unconscious domain of the human psyche harbours the remnants of our infancy and unites us as a biological species through the common experiences that all humans share. Freud (1994) cited dreams, involuntary sensations often experienced during sleep, as evidence that the unconscious psychic realm exists. Characteristic of the ‘*id*,’ or primitive mental agency, are the bodily instincts that give rise to drives or psychic energy, which flow through the dynamical conscious/unconscious system. The quantity of this energy, in other words, how much an individual invests, defines the economic aspect of the psychic process.

A young child makes the distinction between himself/herself and others, gradually developing a sense of unity from all the sensations he/she experiences. Freud (1991) calls this capacity to organize mental processes the ‘*ego*.’ In his model of the psyche, the ‘ego’ arises from the sensitive period when an infant first divides himself/herself from his caregivers and recognizes that he/she is a separate entity. Narcissism, or intense self-absorption, is the starting place of the ‘ego’:

> The development of the ego consists in a departure from primary narcissism and gives rise to a vigorous attempt to recover this state. This departure is brought about

> by means of the displacement of libido on to an ego ideal imposed from without; and satisfaction is brought about from fulfilling this ideal. (Freud, 1991, p. 30)

According to Freud (1991), the young child must make a tremendous economic investment in his/her effort to differentiate himself/herself. Beginning with that experience, it becomes the desire of humans to articulate who they are by identifying with a model outside themselves. In this respect, our earliest social interactions form the basis for an '*ego ideal*', those specific identifications to which the 'ego' strives, and the desire for which is rooted in the 'libido', or human sexual instincts.

Erikson (1958) defined 'libido' as a broad range of "instinctual drives and inborn motivational forces" not limited to sexuality, thereby converting Freud's "psychosexual view" to a "psychosocial rendition" (Hoare, 2005, p. 21). Erikson (1980) argued that the social experience of maternal care is necessary in order for the infant to survive. The 'ego' functions as a 'go-between,' reconciling the bodily needs of the 'id' with the expectations of human society, and it is fitting to think of the 'ego' as the "meeting point, the point of conjunction, between the body and the social" (Grosz, 1994, p. 32). According to Erikson (1994), the 'ego' forms within social experiences, which give the young child an opportunity to identify with others who attract his/her attention. In the process, he/she makes a self-comparison, and "seeks happiness in trying to resemble" these models (p. 47).

If the individual succeeds, he/she attains *self-esteem*, "a not too convincing facsimile of his original narcissism and sense of omnipotence" (Erikson, 1994, p. 47). Self-esteem, a feeling of well-being for which one strives, is attached to '*ego identity*,' the force that provides psychodynamic consistency over an individual's life course:

> For unlike the infantile sense of omnipotence which is fed by make-believe and adult deception, the self-esteem attached to the ego identity is based on the rudiments of skills and social techniques which assure a gradual coincidence of functional pleasure and actual performance, of ego ideal and social role. The self-esteem attached to the ego identity contains the recognition of a tangible future. (Erikson, 1980, p. 39)

It is a characteristic of being human that we model ourselves after others, whilst playing various social roles. Social roles are performed by individuals as social actors, and we develop many role-specific selves through our diverse experiences. Consequently, the Self is composed of multiple role-specific selves, corresponding to various lived social experiences, which are ready to emerge when prompted by the unconscious 'ego identity.'

In Erikson's (1980) model, the conscious "I' provides the ego with a conduit to an individual's social and physical milieu, and facilitates "reflexive consciousness" (Cote & Levine, 2002, p. 106). Reflexive consciousness is the mental faculty that allows people to see themselves as objects, and in so doing, map their life course. (I further develop the idea of the reflexive process in a later section.) '*Ego identity*' refers to "the ability of the ego to sustain a sense of temporal-spatial continuity, especially in the face of flux and change" (Cote & Levine, 2002, p. 106). Erikson's (1980) assumption that humans desire mastery, and thus a consistent life course, is a common theme that runs through his work.

> Ego identity, then, in its subjective aspect, is the awareness of the fact that there is a selfsameness and continuity to the ego's synthesizing methods and that these methods are effective in safeguarding the sameness and continuity of one's meaning for others. (Erikson, 1980, p. 22).

To remain healthy, the ego needs appropriate challenges in synthesizing and executing an individual's actions. The synthetic functions of the ego determine the meaning of situations, and the executive functions select social-selves, thereby managing impressions

(Cote & Levine, 2002).

Erikson (1994) scoped out a series of eight crises, beginning in early childhood, which people must weather in order to grow and mature. The major crisis faced by adolescents is "Identity vs. Identity Confusion" (Erikson, 1994, p. 94). Rejecting socially imposed roles is symptomatic of this pivotal point in the life course. Resolving the crisis, and thus acquiring a secure identity requires the adolescent to engage in purposeful activity, effectively anticipate various social roles, develop the strength to be himself/herself, and embrace mutually beneficial connections with other people (Erikson, 1994, p. 94). Ego identity calls attention to "certain comprehensive gains which the individual, at the end of adolescence, must have derived from all his pre-adult experience in order to be ready for the tasks of adulthood" (Erikson, 1980, p. 108).

Ego identity is tempered by an individual's unique life circumstances in the context of human society. Erikson gave ego identity a social as well as a psychoanalytic definition, and distinguished it from personal identity or "the normal way we are seen and interpreted by others" (Weigert et. al., 1990, p. 7). The unconscious 'ego' protects our coherency by "screening and synthesizing, in any series of moments, all the impressions, emotions, memories, and impulses which try to enter our thought and demand our action, and which would tear us apart if unsorted and unmanaged by a slowly grown and reliably watchful screening system" (Erikson, 1994, p. 218). The 'ego' serves to manage our inner emotional life, and what we remember about it.

Erikson (1980) recognized that the workings of identity occurred on multiple levels. Generally speaking, identity refers to a "conscious *sense of individual identity*;" at an additional level "to an unconscious striving for a *continuity of personal character*; at a third, as a criterion for the silent doings of *ego synthesis*; and finally, as a maintenance of an inner *solidarity* with a group's ideals and identity" (Erikson, 1980, p. 109). Erikson's (1980) conception of 'identity' relates to an individual's psychodynamic consistency or selfsameness, yet connects him/her to a group through the sharing of his/her temperament with others. This experience, in Erikson's (1980) words, is such that "the young individual must learn to be most himself where he means most to others – those others, to be sure, who have come to mean most to him" (p. 109). In this manner, identity provides an individual with a consistent core, yet links him/her to a group in which he/she engages in mutual relationships with others.

Emotional Subjectivity

As I have previously discussed, Freud's (1991) focus on the social aspects of human development concerned how an individual's mental life was shaped by the involvement of a model outside himself/herself. Jacques Lacan (2006) later referred to this infantile, self-defining experience as "the mirror stage," which may provide "a matrix or ground for the development of human subjectivity" (Grosz, 1994, p. 39). This juncture, in which a young child distinguishes his/her own body, leads to his/her developing a subjective or personal view of other people and himself/herself. Subjectivity is a process in which we formulate personal-emotional judgments by assimilating accessible, as well as dormant, psychic material. Emotions refer to the spontaneous feelings that indicate aroused mental states or passions.

Deleuze and Guattari's (2007) "white-wall/black-hole system," may be thought of as a provocative, and avant-garde, metaphor for human-emotional subjectivity. Accordingly, it forms at the intersection of 'significance' and 'subjectification,' which represent two diverse semiotic schemes. Significance is the conscious aspect of subjectivity, which manifests itself as the outward expression of the meaning that one wishes to convey. Subjectification refers to the movement of unconscious linguistic elements, which influence self-determination. A succinct statement merges the two concepts:

> Significance is never without a white wall upon which it inscribes its signs and redundancies. Subjectification is never without a black hole in which it lodges its consciousness, passion, and redundancies. (Deleuze & Guattari, 2007, p. 167)

Far from transparent, human-emotional subjectivity is a 'becoming' or a formative process involving conscious and unconscious forces, a coupling of fluid rather than static entities. Applying the metaphor to human social experiences, Deleuze and Guattari (2007) defined "faciality" as a set of qualities that resonate particular feelings about someone (i.e., he/she is happy or sad, friendly or angry). Residing at the intersection of significance and subjectification, 'faciality' refers to characteristics of the human face that allow us to connect emotional meaning to the expressive gestures or transmitted signals of another person. Shifting my focus to *Meadian identities,* I continue this examination of gesture in the next section.

The Reflexive Process

Meadian identities or social identities are associated with George Herbert Mead (1967), who described the organization of the social act as a conversation of gestures, which "may be either conscious (significant) or unconscious (non-significant)" (p. 81). Gestures become

the "significant symbols" of a language when they, implicitly and explicitly, communicate mutually understood meanings to others, as well as to the individual himself/herself. Language is a collection of symbols linked to content that is consistent across the experience of people. Conversation refers to active interactions between individuals, where the actions of one person stir up a response in another or others.

Mead (1967) formulated the mind as a social phenomenon, which arises and develops according to social processes, "within the empirical matrix of social interactions" (p. 133). The reflexive process, involving self-consciousness, is the key element in our mental development:

> It is by means of reflexiveness – the turning-back of the experience of the individual upon himself – that the whole social process is thus brought into the experience of the individuals involved in it; it is by such means, which enable the individual to take the attitude of the other toward himself, that the individual is able consciously to adjust himself to that process, and to modify the resultant of that process in any given social act in terms of his adjustment to it. (Mead, 1967, p. 134)

In the reflexive process, an individual internalizes the actions/attitudes of another person, and then modifies his/her response to suit. This suggests that the conversation of gestures is internal as well as external. Thinking, a conversation in our minds, is self-reflective and precedes our socially-motivated actions:

> In reflective intelligence one thinks to act, and to act solely so that this action remains a part of a social process. Thinking becomes preparatory to social action. The very process of thinking is, of course, simply an inner conversation that goes on, but is a conversation of gestures which in its completion implies the expression of that which one thinks to an audience. (Mead, 1967, p. 141)

Human intelligence, our capacity for thought and reason, rests on the rational process of reflexiveness. The end result of the reflexive process is an individual's outward display of his/her inner conversation of gestures to another person or a receptive group of people.

According to Mead (1967) the '*self*' is reflexive and arises through the process of social experience and activity. The 'self' has the unique quality of being "an object to itself," which "distinguishes it from other objects and from the body" (Mead, 1967, p. 136). The 'self' is both subject and object, and represents the part of us that can adopt the outlook of others. Mead's (1967) "I" instantaneously reacts to the act of the 'self' taking the attitudes of others, an experience referred to as the "me:"

> The "I" is the response of the individual to the attitude of the community as this appears in his own experience. His response to that organized attitude in turn changes it. … The "I" appears in our experience in memory. It is only after we have acted that we know what we have done; it is only after we have spoken that we know what we have said. The adjustment to that organized world which is present in our own nature is one that represents the "me" and is constantly there. (p. 196)

The 'self' is acquainted with itself, and at the same time others are acquainted with it, which is a requirement of its existence. Constructed socially, the 'self' connects the individual to a community or a group of people whose relationships are forged through social interactions. Mead (1967) set up a dynamical system in which the "I" represents the spontaneous aspect of the reflexive process, and the "me" serves as a social anchor, mooring a person to human society. Within the "I-me" system, these two elements are continuously at play, improvising rather than orchestrating each ephemeral outcome. Accordingly, Mead (1967) embraced the unpredictable nature of human behaviour, which, from a broad and collective perspective, requires society always to transform as well.

Social Interaction

Continuing to develop the notion of *Median identities*, I discuss the work of Herbert Blumer (1986) and the school of symbolic interactionism. A steward of Mead's (1967)

work, Herbert Blumer (1986) referred to "the conversation of gestures" and "the use of significant symbols" (two types of social interaction) as "non-symbolic interaction" and "symbolic interaction" respectively (p. 8). The three principles of symbolic interactionism are that: (1) people act toward a situation based on its personal meaning; (2) the meaning of a situation is derived from social interaction with other people; and (3) such meanings are processed, adjusted, and used by the individual who encounters the situation (Blumer, 1986, p. 2). Rather than simply reacting to each other's actions, symbolic interaction characterizes our human tendency to make sense of social circumstances that are presented to us. The human 'self' enables personal and social interactions to occur. Social action, the fundamental unit of society, is carried out by a social actor on the premise of his/her interpretations; and as a group, these actions compose "organizations, institutions, and vast complexes of interdependent relations" (Blumer, 1986, p. 49).

Any action directed at another that succeeds in communicating the message intended by the social actor, and consequently prompts a mutually anticipated exchange, fits the description of a gesture. Blumer (1986) suggests that 'gesture' operates in accordance with Mead's three-part definition of meaning:

> It (gesture) signifies what the person to whom it is directed is to do; it signifies what the person who is making the gesture plans to do; and it signifies the joint action that is to arise by the articulation of the acts of both. (p. 9)

The result of a gesture is a two-way process of analysis and classification. "Symbolic interaction involves *interpretation*, or ascertaining the meaning of the actions or remarks of the other person, and *definition*, or conveying indications to another person as to how he is to act," the outcome of which is a particular social interaction that has a similar meaning to both parties, and encompasses the full range of human relationships (Blumer, 1986, p. 66).

Elucidating individual analysis and classification, symbolic interactionism is concerned with *how* people align their actions with one another to suit their unique circumstances.

Concerning how people present themselves to others, and in turn, how others perceive them, Anselm Strauss (2007) used the term '*identity*' juxtaposed with the descriptive words "mirrors" and "masks:"

> Everyone presents himself to the others and to himself, and sees himself in the mirrors of their judgments. The masks he then and therefore presents to the world and its citizens are fashioned upon his anticipation of their judgments. The others present themselves too; they wear their own brand of mask and they get appraised in turn. It is all a little like the experience of the small boy first seeing himself (at rest and posing) in the multiple mirrors at the barber shop or in the tailor's triple mirrors. (p. 11)

Each person wears a veneer that he/she presents to a society comprised of people wearing their own facades. Social actors stage their performances, which are assessed by themselves and others. Self-assessment necessitates taking into consideration, and anticipating, other people's responses. According to Strauss (2007), in the theatre of life an individual's future act is a "complicated mirror," as the cast and their roles are constantly changing (p. 36).

Strauss (2007) placed particular importance on "naming," which is how people classify themselves and others. Names may reveal the categorization of both the self and the act. A "stigma" refers to a "failing, a shortcoming, a handicap" and many other labels that are "deeply discrediting" (Goffman, 1986, p. 3). On the other hand, the stigmatized or unfavourably labelled individual may believe that he/she is "normal" and deserves to be treated like everyone else. Goffman (1986) modelled this scenario by setting up a disjunction between "actual social identity", which includes concrete personal attributes

such as "occupation" and "virtual social identity," or those qualities that describe a person's "character" (p. 2).

> *A* discrepancy may exist between an individual's virtual and actual identity. This discrepancy, when known about or apparent, spoils his social identity; it has the effect of cutting him off from society and from himself so that he stands a discredited person facing an unaccepting world (Goffman, 1986, p. 19).

The stigmatized individual is subject to rejection by the "normals" or people who do not share his/her label (virtual identity). However, it is possible that some normals will see the stigmatized through the lens of his/her actual identity. Goffman (1986) called this set of normal people "the wise," who may have gained their wisdom from working for an institution that serves the needs of people with a particular type of stigma, or they may be people who have a personal relationship with a stigmatized individual (p. 29). The "wise" are sympathizers and/or advocates for people with stigmas.

A stigmatized individual may act suspiciously towards any unwarranted attention paid to him/her by an outsider or a concerned group. On the other hand, he/she may adopt the attitudes of normal people when assessing the apparent severity of those who share his/her stigma (Goffman, 1986). Such judgments about who is normal and who is stigmatized, and if so, to what extent, are largely subject to individual points of view:

> The normal and the stigmatized are not persons but rather perspectives. These are generated in social situations during mixed contacts by virtue of the unrealized norms that are likely to play upon the encounter. (Goffman, 1986, p. 138)

Identity norms are socially constructed by people, and serve to subjectively distinguish conformers from non-conformers. In that respect, deviations from the norm are expected, and vary according to the established patterns of behaviour at a particular time and place.

Goffman (1986) argued that identity norms, which naturally give rise to individual stigmas, also necessitate stigma management by the affected individual:

> The issue is not that of managing tension generated during social contacts, but rather that of managing information about his failing. To display or not to display; to tell or not to tell; to let on or not to let on; to lie or not to lie; and in each case, to whom, how, when, and where. (Goffman, 1986, p. 42)

The stigmatized individual carries his/her own burden of potentially harmful information, and he/she must decide how honest to be with others about his/her stigma. These types of decisions are not limited to people with obvious stigmas; rather, they extend to people in general. We are all performers, who must ultimately select our "act."

Goffman (1959) described the "dramaturgical performance" wherein the performer stages a particular character using methods of "impression management" (p. 208). In plain view of an audience, an individual's "performance" includes all his/her actions that support a "front" or the set character-image displayed (p. 22). The performer can do this intentionally, employing expressive tools such as fashion and body language, or they may do it without knowing the impact that they are having on others. The act of performance has the result of splitting the individual into two parts: a "performer" (controller), who is the "fabricator of impressions," and his/her "character" (role), which possesses the "spirit, strength, and other sterling qualities the performance was designed to evoke" (Goffman, 1959, p. 252). Performers retain control over the characters they display, yet at the same time, they 'become' them.

George J. McCall and J. L. Simmons (1978) related individual role performances to social roles, in which "social roles" refer to a "set of expectations held toward the occupant of a

particular social status or position in a social system", and the act of adhering to those expectations defines a "role performance" (p. 6). In terms of social interaction, the individual's perceived notion of what his/her audience anticipates may change the nature of his/her performance. These adjustments employ the reflexive process, which has three components: "the active aspect (self as performer), the reactive aspect (self as audience to that performer), and the phenomenal aspect (self as character performed)" (McCall & Simmons, 1978, p. 83). Within social interactions, the actor plays his/her role, and serves as a critical witness to it. Ultimately, the individual becomes an improvised version of who he/she wishes to be.

Performances are complex and rarely involve just one social role, which may also be referred to as role identity or social identity. Each individual possesses multiple social identities corresponding to his/her various social categories, which may be shared by many other people. Social identities differ from personal identities, which exclusively belong to individuals. People legitimize their social identities by performing in accordance with social expectations. Institutions may govern how various social interactions occur by enforcing boundaries or social-structural constraints (McCall & Simmons, 1978). Opportunities for social interaction also vary according to personal and historical boundaries, which may coincide with personal characteristics such as health, gender, and/or race.

McCall and Simmons (1978) asserted that individuals prioritize each social identity in a "prominence hierarchy" (alternately referred to as "ideal self") according to its salience or relative importance, determined by certain criteria:

> The over-all salience of a given role-identity, then, is the resultant of five factors: (1) its prominence; (2) its need of support; the person's need or desire for the kinds and amounts of (3) intrinsic and (4) extrinsic gratification ordinarily gained through its performance; and (5) the perceived degree of opportunity for its profitable enactment in the present circumstances. (pp. 81-82)

Role identities cannot exist in a vacuum; their survival depends upon social variables. Some gain prominence and others are discarded, assuring that role identities vary with the constant ebb and flow of social life. Those that deliver satisfaction to the individual, and are supported by others, are likely to gain prominence. Actions that provide intrinsic gratifications are enjoyable. Material objects and experiences that provide extrinsic gratifications are useful to an individual for realizing his/her aspirations (McCall & Simmons, 1978, p. 147). A person may possess role identities that would thrive in a different situation, but based on the current state of affairs, never get the opportunity to come into view. An individual's quest for role support is distinguished from his/her need for legitimatization:

> Such support is merely a kind of social evidence shoring up one's claims to the identity, whereas the individual himself wishes to *enact* his roles, to fulfil his imaginings, to live according to his role-identities. The individual wants very much *to be and to do* as he imagines himself being and doing in a particular social position. (McCall & Simmons, 1978, p. 72)

From an individual's perspective, the desire to legitimate an identity is as essential to its existence as its need for support. Mentors or teachers may help an individual legitimize and sustain an otherwise fleeting role identity by offering him/her opportunities in which to enact it. Individuals place more importance on role identities that have a high degree of salience for themselves, and spend less time developing lower-order role identities (McCall & Simmons, 1978).

Examining role identities as collections may reveal patterns within a particular context, which indicates "cohesiveness:"

> The over-all organization of role-identities also varies in degree of *cohesiveness*, that is, in the extent to which separate role-identities are tightly or loosely interrelated. In most cases, they seem to "cluster" in smaller numbers of subpatterns. The basis for this clustering is ordinarily that several role-identities involve similar skills, have the same persons "built into" their contents, or pertain to the same institutional context or period of one's life. These clusters may themselves be linked more or less closely with other clusters or may be rigidly "compartmentalized" or disassociated from others.
> (McCall & Simmons, 1978, p. 74)

Constellations of role identities are often acknowledged, as certain role identities are likely to occur in conjunction with compatible others. Nevertheless, juggling roles challenges an individual, as it is difficult to avoid confusion. Staging problems occur when the performance of one role identity interferes with another (McCall & Simmons, 1978).

Unequal social roles within interpersonal interactions may lead to power struggles, which indicate that there is an imbalance of "exchange resources" such as "money, status, authority, knowledge, equipment, sex, strength, skills, and so on" (McCall & Simmons, 1978, p. 155). These exchange resources provide support for various social roles, and are likely to facilitate control over certain social interactions. Nevertheless, exchange resources can also temporarily tip the balance of power in an unexpected direction. In this case, 'trust', or one's reliance on the integrity and talent of others, impacts social interactions, and thus the roles that people play.

On the topic of feelings, Helen Merrell Lynd (1965) explored the emotion of shame in conjunction with identity. The feeling of shame stems from the unexpected revealing of an aspect of an individual's identity that he/she may not be prepared to share:

> Experiences of shame appear to embody the root meaning of the word – to uncover, to expose, to wound. They are experiences of exposure, exposure of peculiarly sensitive, intimate, vulnerable aspects of the self. The exposure may be to others but, whether others are or are not involved, it is always … exposure to one's own eyes. (Lynd, 1965, pp. 27-28)

Shame is an example of an emotion that profoundly changes the way an individual sees himself/herself. The fact that other people may alter their view of the shamed person is of secondary importance. Because the sudden illuminating of inappropriateness throws his/her world askew, shame endangers the trust he/she extends both outward and inward, and is thus an experience of the whole self (Lynd, 1965). Experiences of shame involving the whole self hint at identity:

> Separate, discrete acts or incidents, including those seemingly most trivial, have importance because in this moment of *self*-consciousness, the self stands revealed. Coming suddenly upon us, experiences of shame throw a flooding light on what and who we are and what the world we live in is. (Lynd, 1965, p. 49)

This aligns with the sociocultural idea that identity and social context are inextricably linked. It is a painful experience to lose an identity because of changes in personal relationships and transformations of previously stable situations (Lynd, 1965, p. 37). The issue of identity and emotions appears in the next section, which presents a comprehensive working definition of identity.

Identity

Weigert et al (1990) artfully summarized a sociological approach to identity that builds on the work of Erik Erikson, who, they argue, influenced the two schools of Symbolic Interactionism: Chicago (e.g., Herbert Blumer, Anselm Strauss and Erving Goffman) and Iowa (e.g., George J. McCall and J. L. Simmons). It is not my intention to report on the Chicago School's and the Iowa School's complex historical-theoretical roots. Cote and

Levine (2002) provide an analysis of this topic. However, in a condensed manner, I may state that a major difference between the two schools is Chicago's emphasis on the process-oriented and emergent qualities of identity, versus Iowa's focus on identity's structural or fixed characteristics (Cote & Levine, 2002, p. 32).

Combining this broad range of work, Weigert et al (1990) suggest a comprehensive working definition of identity. Though I have utilized it previously, I present it again along with its supporting information, in a useful and consolidated format:

(My comments on the italicized material serve to relate the literature that I have reviewed thus far.)

> Identity *is a typified self at a stage in the life course situated in a context of organized social relationships.* (Weigert et al, 1990, p. 53)

Viewing 'identity' through a wide-angle lens, this definition pulls together Erikson's (1980, 1994) notion of the life course, Mead's (1967) concern for the social, and anchors it to the structural elements articulated by McCall and Simmons (1978).

The above definition is justified by twelve Propositions of Identity Theory (Weigert et al, 1990):

1. *Meanings are realized – that is, become known and behaviorally real – in mutually oriented responses according to the taken-for-granted structures of society, especially power and trust.* (p. 36)

Proposition 1 refers to how people live in, and interact with, a world that is not entirely of their own making. They must make sense of, and hence find meaning in, many social structures that are imposed upon them. I mention 'power' and 'trust' when discussing McCall and Simmons (1978), and Lynd (1965).

2. *Humans act toward things as objects on the basis of the meanings these objects (including humans) have for them.*
3. *Meanings emerge from symbolic interaction.*
4. *Meanings are grasped and applied through processes of learned interpretations.* (p. 37)

Propositions 2-4 echo Mead's (1967) discussion of the reflexive process, and Blumer's (1986) symbolic interaction. On the other hand, these propositions appear to contradict Proposition 1, a tension that represents the dialectic between society and the individual, which I later discuss in my Methodology (Chapter 3) (Weigert et al, 1990).

5. *Typical responses and meanings are formally and differentially objectivated in social institutions*. (p. 38)
6. *Individuals become human as social selves by internalizing the institutionalized structures of meaning, such as language, interpretive procedures, action and feeling rules, social class perspectives, and so on.* (p. 39)
7. *Self is a multidimensional, reflexive, experiential process involving knowledge and emotion shaped by the individual's roles and social position.* (p. 42)
8. *Dimensions of self are transformed into meaningful objects as subjective and objective identities at the analytical levels of ego, individual, group, organization, and society.* (p. 46)
9. *Multiple identities are enacted according to salience hierarchies based on the a priori institutional order, the felt probabilities of success, and the dramaturgical skills of the performers in the situation.* (p. 47)

Propositions 5-9 refer to the structural aspects of identity, such as institutions, social positions, and salience hierarchies, which I discussed when reviewing the work of McCall and Simmons (1978). Proposition 8 harkens to Erikson's (1980) statement that identity works on many levels, and is included in my review. Proposition 9 makes mention of the "dramaturgical skills" elaborated on by Goffman (1959).

10. *Multiple identities are communicated through displays of appearances, behaviour, and language.* (p. 50)

Proposition 10 refers to the act of self-presentation and impression management, which was fully developed by Strauss (2007) and Goffman (1959, 1986).

11. *Commitment to identities results both voluntarily and involuntarily from an individual's biography, which incorporates both position in the social structure and stage in the life course.* (p. 52)

Proposition 11 is concerned with the structural elements of identity and Erikson's (1980) ideas about the individual life course.

12. *Selves are committed to roles that are relevant to their identities.* (p. 52)

Proposition 12 considers identity commitment, which relates to the salience hierarchy offered by McCall and Simmons (1978).

Weigert et al's (1990) twelve Propositions of Identity reveal five issues concerning identity: (1) "*The dialectic of subjective and objective identity"* (p. 54), (2) "*The sociohistorical availability of identities"* (p. 56), (3) "*The organization of multiple identities"* (p. 57), (4) "*The continuity of identity"* (p. 60), and (5) "*Identity and emotions"* (p. 62). The first issue brings to light the tension between the individual self and the society in which he/she lives. The dialectic is illustrated by Goffman's (1986) stigmatized individuals as they experience contradictory identity norms, and is a concern that I take up in more theoretical depth in my Methodology (Chapter 3). The second issue calls attention to identity availability, which depends upon the unique circumstances of many social factors such as time, place, and appropriateness. People do not have equal access to many of the available identities at every juncture, nor do available identities remain constant throughout history. The third issue opens up questions about how individuals manage their multiple identities when confronted with challenges such as role confusion, power struggles, and stigmas. The fourth issue concerns the factors necessary for identities to endure, or not, over the life course. Structural elements favourable to identity continuity are high salience, role support, and exchange resources. The fifth issue, identity and emotions, is illustrated by the whole-

self involvement in the emotion called shame, which Lynd (1965) explored. All five issues come into play in the sociocultural framework that I discuss in the next section.

Developmental Concepts

The sociocultural framework combines the social perspective of identity, which I have presented thus far, with *developmental concepts* found in the work of Lev Vygotsky. Vygotsky (1978) formulated an approach to the semiotics of higher-order behaviour (as opposed to elementary or unmediated behaviour), in which an individual uses a combination of *tools* and *signs* in psychological activity. *Tools* are practical mechanisms (external or internal) that help us to accomplish a particular task. Higher-order behaviour commences when a young child employs words to steer his/her activities, and this milestone marks the juncture where *signs*, which are fabricated stimuli, begin to emerge in his/her mental life. Semiotic mediation, the use of tools and signs, provides children with a means of control or agency over their world and themselves.

Each individual's development can be charted according to his/her use of tools, along with aspects of his/her biological progress:

> *T*he child's system of activity is determined at each specific stage *both by the child's degree of organic development and by his or her degree of mastery in the use of tools.* (Vygotsky, 1978, p. 21).

Tools are an important indicator of human physical and intellectual growth. Vygotsky (1978) argued that linking the use of tools and speech forms a dynamical system that influences psychological behaviour such as "perception, sensory-motor operations, and attention" (p. 31). As instantaneous causes of behaviour, signs are "self-generated" stimuli that extend the memory or recollection process (Vygotsky, 1978, p. 39). It becomes the

child's convention that speech is directed inward, such that language serves an "*intrapersonal function* in addition to its *interpersonal use*" (Vygotsky, 1978, p. 27). Planned action is mediated by internalized speech, a process that joins the inner life of the mind with outward social interactions, and that one learns over time.

When assessing Vygotsky's (1978, 1986) work, one notices a few important parallels with Mead (1967), reflecting common intellectual influences beginning with Hegel's (1977, 1991) dialectical groundwork (Valsiner & Van Der Veer, 1988 p. 125). (I talk about these foundational and ontological ideas in the Methodology section of Chapter 3.) Vygotsky's formulations were based on scientific psychology, whereas Mead's work centred on the dynamic interactions linking the self and its social roles (Valsiner & Van Der Veer, 1988). Vygotsky focused on "the continuous dialectic between mind and a world that was both social and material and was being changed as it was acted in and on" (Edwards, 2007, p. 84). People act upon their environment and themselves through the use of tools and signs, and the result is that the cultural world changes, and so do we.

Wertsch (1991) summarizes Vygotsky's perspective, which provides essential assumptions for the sociocultural framework:

> Three basic themes run through Vygotsky's writing: 1) a reliance on genetic, or developmental, analysis; 2) the claim that higher mental functioning in the individual derives from social life; and 3) the claim that human action, on both the social and individual planes, is mediated by tools and signs. (p. 19)

Emphasizing developmental themes, Vygotsky recognized that the mind emerges from social life. People use mediational means to negotiate their actions, which vary according to

the place in which they occur. Actions are located in "cultural, historical, and institutional settings" (Wertsch, 1991, p. 15).

As action is mediated by tools and signs, identity is mediated by semiotics in a sociocultural framework, as presented by Holland & Lachicotte (2007):

> In Vygotskian terminology, an *identity* is a higher-order psychological function that organizes sentiments, understandings, and embodied knowledge relevant to a culturally imagined, personally valued social position. Identities formed on a personal terrain mediate one's ability to organize and perform the intention of one's activity in the locales and "occupations" of cultural worlds. (p. 113)

Identities serve to compartmentalize given social roles, and hold various positions for us in society. The sociocultural view recognizes that we may articulate our identities like a language to express ourselves within the complexities of civilization. 'Imagined', in this case, refers to our ability to plan our actions beforehand. The empirical research presented in Part II further elaborates on the sociocultural framework, providing additional theoretical details, and results.

Part II: Empirical Research

Mathematical Identity in a Sociocultural Framework

Chapter 1 introduced 'identity' in a sociocultural framework. In this model an *Eriksonian identity* provides psychological consistency, whilst *Meadian identities*, which correspond to various social experiences or practices, are empowered by Vygotskian *developmental concepts* (Holland & Lachicotte, 2007). Chapter 2, Part I explained the components of this model. Anchored in Freud's (1991, 1994, 2005) psychoanalytic theory, Erickson's (1980) idea of psychodynamic consistency was provided by an unconscious ego identity, which followed an individual over his/her life course. According to Lacan (2006), the ego arises in

"the mirror stage" in which a young child begins to differentiate himself/herself from others. Noting the importance of the reflexive process in which an individual internalizes the actions of others, Mead (1967) set up the dynamic "I-me" system, to formulate the mind as a social phenomenon. Building on Mead's (1967) work, Blumer (1986) called social action, or how people align their actions with others, the basic unit of society.

In my sociocultural framework, identities are mobilized by semiotics, the science of signs. A sign arises when a signifier, meaningless when operating single-handedly, is joined with a signified or a mental construction of something. This is illustrated by a Saussurian fraction in which the signifier hovers above a signified in an ocean of possible associations. It is important to note that the real thing referred to by the sign, or the concrete referent, is of secondary importance to its mental conception (Willis, 2000). Walkerdine (1990) asserted that the practices surrounding school mathematics functioned as a system that produced the sign of the learner of mathematics. It follows that this sign is not the real person, but an abstract signifier/signified pair. Walkerdine (1990) argued that the sign-producing system categorized the learner's capacity to do mathematics. Without using the term 'identity' explicitly, Walkerdine (1990) implies that the learner's mathematical identity is the result of semiotics. Mathematical identity is a Meadian identity (as defined above) associated with the practices of doing school mathematics.

William, Bartholomew and Reay (2004) explored how students negotiate the classification of their mathematical ability through standardized assessments. The authors utilize the results of a study conducted by Reay and William (1999) at an English school in which eleven-year-old students take a national exam in mathematics (as well as English and

science). It is recognized that these assessments also reflect the quality of the teacher's work, which places performance pressure on each classroom, as well as the school as a whole. The mathematics test was 'tiered' so as to create levels of student ability based on the results. From a semiotics perspective, the researchers observed that over the course of the test preparation a metonymic shift occurred in which the students' mathematical identities became their designated levels:

> From thinking of themselves as students who might *get* a particular level, the students changed to talking about themselves as *being* a level three, four, five or six. The causes of this shift are, of course, complex, but there can be little doubt that a major influence was the culture of the school, which had embraced the need to improve its test scores irrespective of the consequences for the students' achievement in wider terms. Students were increasingly valued not for their personal qualities, but rather for what they could contribute to the targets set for the school by the school district. For many of the students in the class, the results of these assessments came to be bound up with not just what kinds of careers might be open to them, but who they were now, who they could be, and even their moral worth. (William, Bartholomew & Reay, 2004, p. 58)

The "naming" of each learner's level served as an important classification of the individual act of completing the assessment in mathematics (Strauss, 2007). By adopting these levels as identities, the learners were produced as signs that carried meanings, which extended beyond their present school setting. The 'real' children who took the tests were discounted in the process, by the school, and by themselves. Within individual prominence hierarchies, the identity associated with a favourable assessment level gained salience because it was supported and opportunistically rewarded by the school (McCall & Simmons, 1978).

van Oers (1996) views mathematics education as a progression of enculturation in which teachers and learners make sense of mathematical practices in society through social interaction. Learners must appropriate the rich cultural heritage of mathematics in their own terms. According to the sociocultural framework, social interaction is "the medium by

which historically developed ways of knowing are transmitted from one generation to the next" (Cobb, Jaworski & Presmeg, 1996, p. 15). Holland et al. (2003) refer to this phenomenon as "figured worlds," which consist of participant-driven traditions that "gather us up and give us form as our lives intersect them" (p. 41). Figured worlds are shaped by social interaction and are accessed by individuals playing specific social roles. Social roles refer to the actions that people perform from vantage points or positions. Holland et al. (2003) assert that figured worlds are the identity-producing divisions of the greater cultural world:

> The identities we gain within figured worlds are thus specifically historical developments, grown through continued participation in the positions defined by the social organization of those worlds' activity. They are characteristic of humans and societies. (p. 41)

Figured worlds create in human society partitions or structural constraints around which identities must be moulded. Structural factors refer to the regulative entities such as exchange resources and gender, which facilitate (or do not facilitate) the formation of specific identities at different times and places (McCall & Simmons, 1978).

Voigt (1996) presents ethnographic data from several studies to provide evidence that learning school mathematics takes place within classroom interactions subject to constraints; for example, the discipline's established protocols and procedures. In one vignette, two boys attempt to "make sense of oddness and evenness of fractions", an impossibility unbeknownst to them, by linking it "to units of time represented on clocks" (Voigt, 1996, p. 24). Even though their effort logically extended known facts, it yielded a conclusion not considered as true by mathematics in general. Such a scenario provided their teacher with an opportunity to offer instruction on the topic, thereby addressing the

students' misconceptions. Mathematical meaning, in this case, was negotiated in the context of routine teaching practices. Voigt (1996) offers an analysis:

> In the negotiation of mathematical meaning, the single meaning and the context of meaning elaborate each other. The potential conflicts of the negotiation are minimized through routines and obligations. As they are constituted, the relations between routines and obligations form (thematic) patterns of interaction. Through the (thematic) patterns, the teacher and the students arrive at mathematical meanings taken to be shared. (p. 41)

Classroom routines and obligations encourage manageable social interactions. Teachers and students carry out "mathematical *themes*", or relationships of mathematical meaning, which are agreed upon by consensus (Voigt, 1996, p. 35). From the student's perspective, the negotiation of mathematical meaning is a reflexive process of internalizing the actions/attitudes of others (Mead, 1967). The 'self' as a learner of mathematics arises from the social experience of doing school mathematics in a learning community. Mead's (1967) "I-me" system suggests that:

> The student has to keep a balance between what she experiences as expected to do, what she wants to do, what she can do, and what she experiences the others do. (Voigt, 1996, pp. 44-45)

Recognizing individual agency, as well as the desires and plans of others, the student forms his/her mathematical identity by digesting the entire social process of doing school mathematics. Keeping a balance, in this case, refers to modifying his/her actions in return.

Boaler and Greeno (2000) explored mathematical confidence as a function of identity and agency in figured worlds. The researchers interviewed 48 high school students, who were studying Advanced Placement (AP) calculus, in six Northern California schools. (The schools primarily served middle to upper-middle class students.) All the students in the study were considered successful math students because they had attained an advanced level. The interviews were semi-structured and focused on the students' experiences with

school mathematics. The results were presented in three segments: (1) students' impressions of mathematics classroom practices, providing a description of the figured world; (2) students' opinions about their position within the figured world; (3) "students' reports about their affective reactions and identifications toward their participation in mathematics learning, in the present and future" (Boaler & Greeno, 2000, p. 175).

The researchers found that the figured worlds of the mathematics classrooms differed. One group of students described a heavily structured and ritualized environment that did not encourage active discussion. The second group depicted a learning environment that relied upon relationships, communication and connection. With regard to positioning, the learners in the ritualized environment accepted "received knowing" that placed primary importance on the teacher as the source of knowledge, whilst the learners in the discussion-based classes employed "connected knowing," where mathematical discussions invited the learners "to consider other people's representations of knowledge" (Boaler & Greeno, 2000, pp. 174, 183).

An interesting outcome was that students who rejected school mathematics in the didactic, or ritualized environment, did so for reasons other than their ability:

> When students talked about their rejection of mathematics, their reasons went beyond cognitive likes and dislikes, to the establishment of their identities. They talked not about their inability to do mathematics, but about the kinds of person they wanted to be – creative, verbal, and humane. (Boaler & Greeno, 2000, p. 187)

Accordingly, these competent math students rejected school mathematics because of the rigid teaching practices, which left them little room to exercise creativity or use language, an important aspect of their identities. Thus, instead of mathematics, they wished to study courses that incorporated opportunities for "expression, interpretation, and agency"

(Boaler & Greeno, 2000, p. 187). Nevertheless, the emphasis upon received knowing was appealing to some learners, who described a positive identification with mathematics:

> It seems striking that the students in didactic classes who liked mathematics did so because there were only right and wrong answers, and because they did not have to consider different opinions or ideas, or use creativity or expression. (Boaler & Greeno, 2000, p. 185)

These learners enjoyed doing the rote work of school mathematics because it allowed them to tune out the social and political life of the classroom, which they may have considered a distraction. They could succeed by obtaining a correct result, a statement that required little explanation. This contrasts the opinion of a student in a discussion-based class, who said that she liked mathematics, even though she described herself as a "verbal person" (Boaler & Greeno, 2000, p. 188).

At the high schools that offered discussion-based mathematics classes, Boaler and Greeno (2000) found that "15 of the 16 students said that they enjoyed mathematics (94 percent), and 8 out of 10 students asked (80 percent) stated that they planned to continue with other mathematics courses" (pp. 187-188). The researchers conclude:

> The students in the discussion-based environments were not only required to contribute different aspects of their selves, they were required to contribute *more* of their selves. In the discussion-based classrooms students were, quite simply, given more agency. (Boaler & Greeno, 2000, p. 189)

The discussion-based classes gave the learners the opportunity to employ numerous Meadian identities, associated with other disciplines besides mathematics. It follows that in the context of the discussions, each learner may stage a "dramaturgical performance," which allows for expression and agency (Goffman, 1959).

Mathematical identity or 'self as learner of mathematics' exists in conjunction with many other social identities:

> In addition to 'self as learner of mathematics' … is the 'self as pupil', 'selves as learners of other school subjects', as well as 'self as boy or emerging man', 'self as girl or emerging woman', as well as identities associated with social groups, deviancy, etc. … According to the communities of practice the person belongs to other new 'selves' may be spun out and developed. (Ernest, 2004, p. 77)

Social identities emerge when people engage in social interactions within communities corresponding to various activities. These multiple identities are associated with a wide variety of discourses, which may or may not be compatible with the discourse of school mathematics. In the next section, I review two culturally-based studies that examine how the discourse and practices of school mathematics operate in conjunction with identities produced in everyday activities.

Mathematics and Other Activities

Walkerdine's (1990) empirical research links the way children do school mathematics to everyday communication practices, including dialogues concerning meal consumption, and shopping for a family. To support her study in cognitive development, Walkerdine (1990) synthesized the unique characteristics of mathematics as a semiotic system, which may establish how it is transferred between practices. Metaphor and metonymy are two terms used in her analysis, which juxtapose the immediate functioning of the discourse with its long-term pattern of development:

> Metaphor is taken to describe the synchronic aspects of the code, its immediate, coexistent, and vertical relationships. Metonymy represents the diachronic axis – the sequential, successive, and linearly progressive relationships.
> (Walkerdine, 1990, p. 184)

Given their definitions, with respect to mathematics, metaphor and metonymy serve to describe the differences between how the discourse is employed in everyday scenarios, as

opposed to the established discipline taught in schools. Walkerdine (1990) asserts that formal statements in mathematics (such as 2 + 3 = 5) "contain little or no metaphoric content" (p. 184). Much of the discourse of school mathematics is metonymic, which poses a challenge for some learners:

> The peculiarity of mathematical discourse is that, in its written form, it does not allow the entry of metaphoric content and may well be presumed to produce problems for learners, who have to suspend or repress this content in order to operate in mathematics. (Walkerdine, 1990, pp. 185-186)

The metonymic form is maintained by excluding material from other discourses, which could potentially inject metaphoric content. Walkerdine (1990) argues that mastery of school mathematics often requires the learner to maintain a non-personal, objective stance, even though mathematical signifiers imply multiple significations.

Nevertheless, mathematics statements are routinely translated into words and applied to everyday situations. In a model based on Lacan (2006), signifiers create complex chains "in the move from one discourse to another" (Walkerdine, 1990, p. 191). Likewise, when non-mathematical practices are transformed into mathematics, the "signifier/signified relations in one discursive practice" are gradually "shifted through the production of complex chains, ending with the insertion of the new signifier/signified pair" that creates a rationalized discursive practice (Walkerdine, 1990, pp. 186-187).

Walkerdine (1990) uses Rotman (1980) to argue that mastery over mathematics is a dream or a fantasy associated with predicting and controlling events. Freud's (1994, 2005) idea of the unconscious, with its embedded drives and desires, is an important theoretical tenant of Walkerdine's (1990) work, which examines the emotional and subjective features of doing school mathematics. In one of her transcripts, fantasy entered the domain of school

mathematics when children played a shopping game that allowed them to make expensive purchases (items pictured on cards) for small amounts of money. The children used the shopping game to fantasize that they were rich, a position that was not likely available to them in real life. Walkerdine (1990) argues that "*positioning* within the practices is central for the production of a particular reading of the relations within them and how those relations attain value and are regulated" (p. 148). Since the children in the shopping game came from homes in which lack of money was an issue, their reading of the game, and thus its relation to mathematical content, was affected.

Lave's (2003) Adult Math Project investigated how mathematical activity transfers into real life situations. The researchers observed the study's participants as they shopped for groceries, attended Weight Watcher's meetings, and prepared meals at home. The people in the study, who had no advanced mathematical training, received simple arithmetic problems to solve in these settings. Lave (2003) used the study's results to argue that cognition is situated in our daily tasks and that learning transfer occurs when links are made between practices. Shoppers in search of the 'best buy' adjusted their approach to accommodate grocery displays. As a result, solving a problem in the grocery store did not occur in a fixed, predictable format, but was shaped by the unique characteristics of the activity. Lave (2003) asserts that:

> People do not have a math problem unless they have a resolution shape – a sense of an answer and a process for bringing it together with its parts. Problem solvers proceed in action, often integrally engaging body, self, common sensibilities and the setting. (pp. 19-20)

Mathematical problems, or mathematical dilemmas as Lave (2003) prefers to call them, are inextricably bound to their setting. The unit of analysis is the individual acting in a particular context, doing a mathematical activity. The grocery display provides shoppers

with a sales-promoting structure in which to interact, as they use 'unit pricing' to sort through many product options.

Lave (2003) asserts that solving an arithmetic problem "does not take place in a vacuum, but rather, in a dialectical relationship with its settings" (p. 148). The components of a dialectical relationship are integral to a particular quandary:

> A dialectical relation exists when its component elements are created, are brought into being, only in conjunction with one another. (Lave, 2003, p. 146)

Certain things must come together at once in order for a dialectical relationship to occur. A dialectical relationship is not a conglomeration of interchangeable parts. Dialectical relationships reflect complex circumstances in which people adjust their actions, and thus their identities.

Mediated Identities

Vadeboncoeur and Portes (2002) argue that identity construction occurs in the dialectic between social conversations and the wider influences associated with them. Identities are mediated within discursive practices that originate on both an individual and a societal level. Students who are given the label "at risk" or "struggling" may form supportive peer groups of similar individuals. However, these alliances may also separate them from mainstream social life, as in the case of Eckert's (1989) "Burnouts", and Willis's (1981) "Lads", which are group identities of high school students who rejected school-sanctioned discourses such as academic achievement and athletics. Though they adopted the poor school performance widely associated with working class life, Eckert (1989) found that the Burnout group also included dissatisfied male students from higher socio-economic groups.

Barnes (2000) presented ethnographic data from a mathematics class in an upper-middle socioeconomic secondary school to explore how various masculinities enter into collaborative learning scenarios. The third year students in her study were beginning to learn calculus. Barnes (2000) notes that the students were positioned at the "intersection of several powerful but conflicting discourses: notably those of the school, their parents, the mathematics department, the class teacher, and the peer group" (p. 150). Different discourses suggest different role identities, which may or may not be compatible or cohesive in a certain setting (McCall & Simmons, 1978).

Barnes (2000) describes a group of five boys that she calls the "Mates" who tended to dominate the other students in the classroom:

> The physical presence of these boys in the classroom was always noticeable. Their behaviour was restless and attention-seeking; they tended to take up more space than other students, to move around more, and to make more noise. (p. 152)

The Mates used strong physical and vocal gestures to dictate the social interactions within the classroom. These boys liked school as long as they could maintain the centre-stage position of their group. In a collaborative learning environment, the Mates naturally assumed managerial roles.

Nevertheless, Barnes (2000) observed that the Mates acted uninterested when other students assumed leadership roles, and that they often took credit for other students' work. Looking towards the future, these boys aspired to careers in business and medicine. The Mates viewed school mathematics as a stepping-stone on their journey despite the teacher's attempt to make the class interesting:

> In spite of the broad range of applications that the teacher presented, they tended to hold more strongly than others in the class the view that the main importance of

> mathematics is as a credential, a necessary qualification to gain entry into a career or course of study, rather than something interesting or likely to be useful to them personally. (Barnes, 2000, p. 155)

The Mates viewed class activities as necessary work. They mediated their mathematical identities with the procedures of doing school mathematics, rather than the essential mathematical ideas. Attaining high marks in the course was a priority for them, though they covered up this desire by projecting the opposite impression. Their performance appeared to be "primarily for the benefit of others in their group, and only secondly for the teacher and the rest of the class" (Barnes, 2000, p. 162).

On the other hand, Barnes (2000) found that three boys that she called the "Technophiles" did not demonstrate as much social interaction with other students during mathematics class:

> During small-group discussions, the Technophiles usually stuck to the point. They took little part in irrelevant talk, and when they had completed the set task would sit quietly while others chatted. They were very focused on the problem, and on getting a solution as quickly as possible. (p. 156)

By working independently, rather than collaboratively, the Technophiles maintained what they perceived as a superior position to the other students. According to Barnes (2000), one Technophile reported that he liked school mathematics "because of its logic, and preferred to learn by thinking about it by himself" (p. 157). These boys "distanced themselves … by their unwillingness or inability to communicate" (Barnes, 2000, p. 163). The Technophiles' mathematical identities were mediated by the teacher, who praised their effort and skill.

Barnes (2000) argued that the boys that she referred to as the Mates and the Technophiles mediated their identities, in part, through discourses associated with masculinity. Connell (1987, 2000, 2005) demonstrates how masculinity is socially constructed in the context of

various practices and institutions, such as sports teams, the primary masculinity-making enterprise in schools. Group efforts such as these, which play to the strength of a team, promote the collective nature of masculinity (Connell, 2005). The Mates represented a version of hegemonic masculinity, which was demonstrated by how they utilized their network of friends, through constant eye contact and interaction, as well as how they subordinated other students (Barnes, 2000).

In contradiction to the Mate's social performance, is the belief that success in school is a result of individual effort, a discourse of meritocracy:

> Meritocracy assumes that students achieve success according to the merit of their work, and that their performance is the result of natural ability or, in some cases, considerable effort. This model views the individual student as largely responsible for school success, school failure, and everything in between.
> (Vadeboncoeur & Portes, 2002, p. 90)

Meritocracy embodies the values associated with traditional educational models that place the onus of achievement on individual students. The Technophiles, as described by Barnes (2000), aligned their performances in accordance with this dialogue. Learners mediate their identities within the prevailing discourses found in their schools. A component of a sociocultural framework, the issue of institutional context is explored in greater detail in the sections that follow.

A Sociocultural View of Learning Mathematics

The term '*pedagogy*' refers to "a theory of teaching", that is, teaching as "the means to facilitate learning according to the epistemology" (Ernest, 1996). Discussed in greater detail in the next chapter, my epistemology (theory of knowledge) is set forth in Berger and Luckman's (1966) assertion that knowledge is socially constructed and socially distributed.

Theories of mathematical learning such as Social Constructivism support the view that learning school mathematics requires conversation (Ernest, 1996). Conversation includes social interactions that engage the student with others, and it can also mean the student's engagement with written work, and/or mathematical learning materials.

van Oers (1996) characterizes mathematics as a "historically developing sociocultural activity" involving, but not limited to, "problem solving, negotiation and communication, mental organization, symbol formation" and "construction" (p. 96). Since my study is sociocultural, I adopt an eclectic model of learning school mathematics that considers learner identities and participation in a social context.

My unit of analysis is mediated action that is described by the person(s)-acting-with-mediational-means. In my study, the meditational means is the semiotic mediation of identity. To synthesize a sociocultural perspective of learning mathematics, I use Forman's (1996) four key points from van Oers (1996).

> *First, social, cultural, and institutional contexts do more than merely facilitate or impede learning. Social organizational processes are an inherent characteristic of learning – whether or not it occurs in an overtly social context.*
> (Forman, 1996, pp. 116-117)

The learner has a dialectical relationship with his/her institutional context in which mathematical identities may be assigned. There are many variations to the shape this process of negotiation may take. As a result, the learner appropriates a mathematical identity in the process of learning school mathematics.

> *Second, learning needs to be viewed as a form of apprenticeship or a means by which novices become experts through participation in activities within a community of practice.* (Forman, 1996, p. 117)

The learner is an active participant in the sociocultural view of learning school mathematics. Learners form mathematical identities with the social interactions and relationships that they share with teachers/mentors. I develop this concept in greater detail below.

> *Third, learning mathematics is a discursive activity.* (Forman, 1996, p. 117)

The Theory of Social Constructivism supports the assertion that learning school mathematics is conversational (Ernest 1996, 1998).

> *Fourth, learning involves the negotiation of meaning within the context of situated activity.* (Forman, 1996, p. 117)

The individual learner is continuously participating in the dialectic of the social setting. The process of meaning formation parallels the process of identity formation (Berger & Luckmann, 1966).

Pedagogically speaking, Forman (1996) argues that since "learning involves the negotiation of both cultural and personal meaning, then classroom discourse must allow this kind of negotiation process to occur" (p. 118). There are three main arrangements that allow this to happen: legitimate peripheral participation, activity setting, and instructional conversation (Forman, 1996). (Legitimate peripheral participation means the same thing as apprenticeship.) The next sections frame these constructs in terms of learner participation and the semiotic mediation of identity.

Learning and Identity

Wenger (2006) views learning as the ability to achieve understanding whilst engaging in a dynamic process of participation and reification:

> *Learning is first and foremost the ability to negotiate new meanings*: it involves our whole person in a dynamic interplay of participation and reification. (p. 226)

The duality of participation and reification is a process of negotiation. Participation refers to the active involvement of the whole person in an activity. Reification refers to the transformation of people's experiences into congealed forms (Wenger, 2006, p. 58). This view of learning deemphasizes the information and skills-acquisition goal of education. Through participation and reification, learning becomes bound up with the learner's identity:

> An identity, then, is a layering of events of participation and reification by which our experience and its social interpretation inform each other. As we encounter our effects on the world and develop our relations with others, these layers build upon each other to produce our identity as a very complex interweaving of participative experience and reificative projections. Bringing the two together through the negotiation of meaning, we construct who we are. (Wenger, 2006, p. 151)

This description of identity formation as the entangling of participation and reification closely aligns with Berger and Luckmann's (1966) dialectic that recognizes society and the individual in play. Society enters into this model through the individual's relationships with others. Wenger (2006) argues that schools should provide learners with identity-transforming experiences or "experiments of identity" (p. 268).

van Oers (1996) suggested that learning school mathematics is a sociocultural activity. Rogoff (2002) defined three planes of sociocultural activity that refer to different spotlights of participation. The planes of focus are "community/institutional, interpersonal, and personal" (Rogoff, 2002, p. 141). Any given activity may involve one or more of these planes.

In the plane of community/institutional, the metaphor of *apprenticeship* is a unique form of participation that allows the learner to develop a mature participation style within relationships with more experienced mentors (Rogoff, 2002, p. 142). Apprenticeship is also known as legitimate peripheral participation. In terms of school mathematics, this may be encouraged by allowing a student to observe an accountant or an engineer at work on real life problems.

On the interpersonal plane, *guided participation* includes "the processes and systems of involvement between people as they communicate and coordinate efforts while participating in culturally valued activity" (Rogoff, 2002, p. 142). Guided participation is acted out in side by side social interactions in which people's positioning is approximately level. Learning activities such as processing multiple orders (money) for a school sale require its participants to communicate mathematically.

Participatory appropriation is a process of negotiating meaning in the personal plane of participation. It closely resembles Berger and Luckmann's (1966) notion of the society/individual dialectic that is an important component of social identity formation. Thus, learning and identity formation are closely aligned. Individuals transform as a result of participatory appropriation:

> The concept of *participatory appropriation* refers to how individuals change through their involvement in one or another activity, in the process becoming prepared for subsequent involvement in related activities. (Rogoff, 2002, p. 142)

The changes mentioned above correspond to identity shifts that position individuals to engage in other sociocultural activities. This view of learning, in which the individual is

immersed in a situated activity, involves the physical and mental resources of a whole person.

Struggling Learners

This section explores alternative literature related to struggling learners and context. I begin this discussion with the macro-micro issue in sociology, which considers how organized social structures such as schools deal with the individual social interactions within them. Mehan (1991) writes that a macro-micro approach is used in schools to sort students in accordance with their labels, in order to place them in appropriate classes and position them to receive special services. Viewed through a sociocultural lens, the process *assigns* labels such as Attention Deficit Hyperactivity Disorder (ADHD), Oppositional Defiance Disorder (ODD), and/or learning disabilities (LD), which are all concomitant, medically defined diagnoses. These labels function as institutionally imposed identities that indicate a possible source of learners' problems at school.

McDermott (2003) argues that in schools, there is a well-established practice of "displaying, noticing, documenting, remediating, and explaining" learning disabilities (p. 272). The school as an institution organizes special departments that offer services for handling learners' disabilities:

> In their concerted activities, people arrange LD as a context for the management of persons in situ. (McDermott, 2003, p. 274)

McDermott's (2003) main point is that managing LD and/or other social identities requires the participation of many people at the organizational and the personal level. McDermott's (2003) strong assertion echoes Foucault's (1980) ideas about how institutions may

construct the individuals they serve. Specific social interactions support struggling learners in traditional educational environments.

In contrast, real life contexts allow the struggling learner to navigate educational dilemmas in a different way. This contrast is exemplified by McDermott's (2003) observations of an LD child named Adam:

> In Everyday Life, Adam can use any resources to get a job done. If he has to remember a telephone number, he can memorize it, write it down, call information, or ask a friend. School tasks are different from this in that a person is often restricted in what he can make use of; procedure is of the essence. On tests, this trend is exaggerated. What else is a test but an occasion on which you cannot use any of the resources normally available for solving some problem; memory notes or helping friends are now called cheating. (McDermott, 2003, p. 284)

When individuals solve problems in a real life context, they may freely access their social networks, as well as public and private information sources. This scenario is the antithesis of how assessments are administered in schools. McDermott (2003) makes the point that school tests are often administered in a closed manner, requiring learners to demonstrate *individual* proficiency. Depending upon their competency, learners may struggle with school mathematics tests for this reason. William, Bartholomew and Reay (2004) argued that students' mathematical identities mirror the particular role of mathematician that is sanctioned by the school via assessments. By challenging this identity norm, it is possible for students to create their own version of mathematician, whether or not they succeed on tests.

Summary

Part I of this chapter set up a sociocultural theoretical framework to analyze identity and how it is mediated by discursive practices. Part II presented empirical research that explores

the semiotics of how school mathematics mediates learners' identities, and how learners mediate their identities within it. Semiotic mediation of identities associated with other discourses was reported as well. This research demonstrated that mathematical and other identities exist in a complex cultural landscape, which changes over time. I concluded Part II with a review of the literature concerning sociocultural views of learning mathematics. I examined work on the topic of learning and identity, as well as the importance of learner participation. The final section explored one sociocultural perspective on how mainstream schools manage struggling learners. For my sociocultural identity research, this literature stresses the importance of institutional contexts, setting the stage for my epistemology within the Interpretive Paradigm.

CHAPTER 3

METHODOLOGY

Introduction

This chapter presents the research design, methodology and methods in two parts. Part I introduces the Interpretive Research paradigm and provides a justification for an ontology, epistemology, and methodology. Part II defines the case study research approach, and data gathering methods, which attend to the research questions. Utilizing a sociocultural framework, my case studies of individual boys' identities (person(s)-acting-with-mediational-means) aim to provide theoretically grounded descriptions in an organized format. Case Studies encompass multiple data sources in a school context. I study more than one case, but study each case individually (Kennedy, 1979). Part II also presents a plan for analyzing and interpreting the data, ensuring validity and adhering to ethical standards. My discussion of the case study approach includes the limitations of the data and the methods.

Part I: Interpretive Research Paradigm

Ontology, Epistemology, and a Notion of Truth

The term 'paradigm' refers to an overarching philosophy with regards to the nature of reality, knowledge, and truth. The interpretive research paradigm takes the position that individuals construct their realities in a cultural milieu. The purpose of interpretive research is to generate contextual understanding in which universals, if any apply, remain in the background (Willis, 2007). In this framework, people are living actors who "prescribe" and "actualize" their roles in a drama played out in social venues (Berger & Luckmann, 1966). Dialectical thinking applies to how individuals negotiate roles or social identities in cultural

contexts. Berger and Luckmann (1966) described a continuous dialectical process in which each individual adds himself/herself externally into society, whilst at the same time internally constructing his/her own reality. Simply put, the dialectic characterizes how one functions in society:

> *T*o be in society is to participate in its dialectic.
> (Berger & Luckmann, 1966, p. 129)

The dialectical phenomenon of society is that individual identities are often objectively assigned and subjectively appropriated (Berger & Luckmann, 1966, p. 132).

Dialectic arises from the juxtaposition of fundamental differences. It is a process in which one entity is continuously "in play" with one or more other entities. A characteristic of the practice is that if one of the entities departs, the "game" changes or is eliminated altogether. For example, according to Plato (*Phaedo*, 100 c.), there existed an autonomous world of ultimate explanations that could be accessed only through arguments and problems (Popper, 1979, p. 123). Dialectics arose because material ideas, or essences, were positioned far away from their potential discoverers. Infallible divine truth resided apart from the fallible constructions of the human intellect. The Platonic belief in the discovery, as opposed to the invention, of pure mathematics is a similar view. (I use the term 'pure mathematics' to distinguish it from 'school mathematics'.)

Hegel (1977) theorized that individual consciousness was created within a divine realm from the internal movements of the dialectical forces of that divine consciousness. "Different independent self-consciousnesses" arose from the "Notion of Spirit" (Hegel, 1977, p. 110). The term "Spirit" referred to the sum total of individual consciousnesses, which existed in constant opposition, and thus personified the dialectic.

> *C*onsciousness itself is the *absolute dialectical unrest*, this medley of sensuous and intellectual representations whose differences coincide, and whose identity is equally again dissolved, for it is itself determinateness as contrasted with the non-identical. (Hegel, 1977, p. 124)

Hegel (1977) viewed *dialectical unrest* as a fundamental property of human consciousness, a scheme that was adopted by Mead (1967).

Departing from the premise of a divine realm, Popper (1979) hypothesized that the world of ideas was created by man, and exists as one of "three ontologically distinct sub-worlds" (p. 154). In his theory, the first world is physical, the second mental, and the third corresponds to the world of ideas. These three worlds interact through the medium of the second world or "the world of subjective or personal experiences" (Popper, 1979, p. 155). The second world mediates between the first and the third, or in other words, an individual's mental world mediates between the physical world and the world of ideas.

Popper (1979) equated the third world, or the world of ideas, with the products of the human mind. Habermas (1984) writes that individual contributions to it (third world) are "vanishingly small" (p. 78). The theories people produce to address questions typically suggest more questions. In other words:

> The *products* of the human mind immediately turn against it as *problems*. (Habermas, 1984, p. 77)

These problems created by the products of our minds often appear to us as autonomous.

For example, signs and sign systems, human products intended to index subjective impressions, are detachable from the "face-to-face" situations in which they may apply

(Berger & Luckmann, 1966). The human process of objectification, or reification, categorizes these abstract mental products as knowledge. Significations allow knowledge to be ordered, and thus to become privileged and socially distributed in everyday life (Berger & Luckmann, 1966). Technical knowledge, like the advanced school mathematics used in engineering, is an example.

Popper (1979) cites two different meanings of 'knowledge':

> (1) Subjective knowledge, which consists of certain inborn dispositions to act, and of their acquired modifications.
> (2) Objective knowledge; for example scientific knowledge which consists of conjectural theories, open problems, problem situations, and arguments.
> (Popper, 1979, p. 121)

Subjective knowledge is relative, because it is dependent upon individual dispositions and experiences. Objective knowledge, in contrast, is also produced by individuals, yet the formal manner in which it is obtained, and the esoteric style in which it is presented, may make it appear absolute. Objective knowledge taken as fact, such as pure mathematics, hides its relativist origins (Ernest, 1998).

Extending this line of thinking, foundational objective knowledge is translated into uncertain terms, a position that has been heavily debated. Boghossian's (2006) argument typifies the absolutist versus relativist dispute:

> The intuitive view is that there is a way things are that is independent of human opinion, and that we are capable of arriving at belief about how things are that is objectively reasonable, binding on anyone capable of appreciating the relevant evidence regardless of their social or cultural perspective. (pp. 130-131)

The absolutist position asserts that objective knowledge of the world can stand apart from social and cultural contexts. Boghossian (2006) fashioned this rebuttal against extreme relativism, or what he saw as a multiplicity of individual viewpoints valued as knowledge.

Indeed, the sociology of knowledge is social relativity; what is knowledge for one group may not be for another (Berger & Luckmann, 1966).

Nevertheless, to address absolutist concerns, I utilize Ernest's (1998) refutation that relativism placed in context is a defendable premise:

> Epistemologically, contextual relativism acknowledges multiplicity but requires that knowledge, justifications, and conclusions be seen as dependent upon features of the context and be evaluated or justified within principled or rule-governed systems. There is an underlying basis for knowledge and rational choice, but that basis is context-relative and not absolute. (p. 249)

Contextual relativism recognizes multiple perspectives, yet frames the research epistemology within grounded theories and clear boundaries. These theories and boundaries are selected by the researcher in a rational manner. However, it is possible that the researcher would make different choices in a different context.

As a result, "there is no secure foundation that humans can use to decide what is true and what is not" (Willis, 2007, p. 49). In other words, truth is inextricably bound to its context (i.e., pure mathematics is accepted along with the lived experiences of its inventors). Popper (1979) linked the concept of 'truth' to the *descriptive* function of language, which together with the *argumentative* function, make up the higher functions of language (p. 120):

> With the descriptive function of human language, the regulative idea of *truth* emerges, that is, of a description which fits the facts. (Popper, 1979, p. 120)

Truth exists in the language necessary to describe the facts, or the current state of affairs, to someone else. The dialogical quality of truth suggests that it is socially interactive and consensual as well.

Habermas (1984) described the *external world* and the *internal world*, as pertaining to objectivity and subjectivity, respectively:

> Only to the extent that the formal concept of an *external world* develops – of an objective world of existing states of affairs and of a social world of norms – can the complementary concept of the *internal world* or of subjectivity arise, that is, a world to which the individual has privileged access and to which everything is attributed that cannot be incorporated in the external world. (Habermas, 1984, p. 51)

The relationship between the external and internal worlds mirrors the dialectic between society and individual. Indeed, the social world or society is part of the external world that individuals must negotiate. Alternatively, the external world may be referred to as *objective reality* and the internal world may be referred to as *subjective reality*.

Identity is a "key element of subjective reality" that is negotiated within an individual's "dialectical relationship with society" (Berger & Luckmann, 1966, p. 173). Conversely, identity types or social roles are associated with objective reality:

> Identity is a phenomenon that emerges from the dialectic between individual and society. Identity *types*, on the other hand, are social products *tout court*, relatively stable elements of objective social reality (the degree of stability being, of course, socially determined in its turn). (Berger & Luckmann, 1966, p. 174)

Social roles are signs that are used to index our subjective impressions of people. They may also be used by people to manage impressions of themselves. The word 'stable' suggests that social identities may be used to index predictable characteristics of people associated with a given social role.

Identity as a Means of Mediated Action

The term '*action*' closely aligns with Habermas's (1984) description of "teleological action" in which actors employ a *management strategy* to bring about a particular result in a given situation:

> The central concept is that of a *decision* among alternative courses of action, with a view to the realization of an end, guided by maxims, and based on an interpretation of the situation. (p. 85)

According to this view, the individual actor is, in a Popperian (1979) sense, between worlds. The individual mediates the physical world, and the world of ideas, through his or her mental world (Popper, 1979). Nevertheless, in order to make it clear that action is motivated by the individual's dialectical relationship with society, I use the term '*mediated action*' (Wertsch, 1991). It follows that a *mediated action* is a *strategy of negotiation*.

For the purposes of my study, I rely on the work of various social theorists to argue that social identities are a means of mediated action. In this framework, social identities function as a special kind of sign system associated with the objective world (Berger & Luckmann, 1966). Shaw (1994) asserts that individuals actively manipulate identities as signs, to advance their position in society, and to demonstrate their loyalty to social institutions. Holland and Lachicotte (2007) summarize this notion of identity as a means of mediated action:

> Identities formed on personal terrain mediate one's ability to organize and perform the intention of one's activity in the locales and "occupations" of cultural worlds. (p. 113)

Individuals make use of identities to mediate their roles associated with the practices in which they are engaged, such as doing school mathematics. Forming a social identity requires intention and action with respect to social life.

Wertsch (1991) states that the sociocultural approach aims "to explicate how human action is situated in cultural, historical, and institutional settings" (p. 119). Recognizing that the phenomenon of social identity construction is heavily dependent upon the context in which it occurs, Berger and Luckmann (1966) stress that:

> Any theorizing about identity – and about specific identity types – must … occur within the framework of the theoretical interpretations within which it and they are located. (pp. 174-175)

Sociocultural identity research is carried out in relevant social settings using theoretical frameworks that suit the unique circumstances.

Methodological Means

The methodology of my study is to *select an appropriate unit of analysis*. For my research, *mediated action* serves as the unit of analysis that is the primary component of the overall study. My study focuses on mathematical and other identities of struggling teenage boys, and addresses the following research questions (restated from Chapter 1):

1. *How does doing school mathematics mediate the identities of 'struggling' teenage boys?*

   The ways in which struggling teenage boys do school mathematics, including participation and avoidance, may arbitrate their mathematical identities.

2. *How do 'struggling' teenage boys mediate their identities in school mathematics?*

   The ways that struggling teenage boys communicate their mathematical identities reflect possible characteristics of doing school mathematics in a particular setting, for example: rigour, competition, acceleration, and carrying out abstract practices.

3. *How do 'struggling' teenage boys mediate their identities in school mathematics and their identities shaped by other social practices?*

Ways of doing school mathematics may differ, or not differ, from ways of doing other activities, such as athletic sports, suggesting an agreement/disagreement between various social identities, marking compatible/incompatible social roles/positions.

4. *How do the boys' past experiences mediate their present identities in school mathematics?*

   This assumes that a boy's "past is present" as he appears to act on the basis of former experiences (Rogoff, 2002, p. 155).

Matusov (2007) asserts that the research goals should be established before the research methods. The goal of my research is to explore *how* questions regarding the semiotic mediation of identity as it pertains to struggling teenage boys doing school mathematics. This line of inquiry may also inform practice surrounding meeting the needs of struggling teenage boys.

Working Theory

Designed as a working component of my study, the table that follows synthesizes Wertsch's (1998) **"*Ten basic claims*"** about mediated action, on the left hand side, with the structural and emergent properties of social identities, on the right hand side (p. 25):

"M*ediated action is characterized by an irreducible tension between agent and mediational means*" Agent and mediational means are elements of a system that exists in a state of dynamic tension (p. 27).	A tension may exist between the individual and the social identities that are imposed on him or her, within certain practices. An example is the active resistance of Goffman's (1986) stigmatized individuals.
"M*ediational means are material*" Agents change as a result of employing material objects as cultural tools or mediational means (Wertsch, 1998, p. 31).	Material items taken from everyday life can communicate social identities. Willis (2000) articulates this phenomenon when he writes: The elements of a cultural

Materiality is not necessarily a tangible characteristic.	practice mutely 'speak' – clothes, body, style, demeanour, interaction, the use of commodities – of many things, but importantly of the actual social and physical locations of the cultural participants. (Willis, p. 12) Material artefacts or commodities that correspond to an identity associated with a particular sub-culture are most important in applicable settings. "Multiple identities are communicated through displays of appearances, behaviour, and language" (Weigert et al, 1990, p. 50).
"M*ediated action typically has multiple simultaneous goals"* Mediated action is motivated by multiple goals and purposes, which interact and conflict with one another (Wertsch, 1998, p. 32)	The decision-making aspect of action makes it reasonable to assume that actors may employ multiple strategies at the same time. Individuals may select a cluster of social identities in order to stage a particular performance (McCall & Simmons, 1978).
"M*ediated action is situated on one or more developmental paths"* Mediated action is situated in a historical context. "Agents, cultural tools, and the irreducible tension between them" are anchored in the past, yet continue to change over time (Wertsch, 1998, p. 34).	From the individual's perspective, the dialectic in society that produces his or her identities has internal and external components (Berger & Luckmann, 1966). Shaw (1994) asserts that the sign system of identity relates to psychological as well as social development: Identity … is a "signifying practice" and refers to people's use of a range of sign vehicles in an ongoing process of communication that is both intrapersonal and interpersonal and that simultaneously serves both psychological and social functions. (Shaw, 1994, p. 84) Identity facilitates inwardly and outwardly directed communication. "Commitment to identities results both voluntarily and involuntarily from an individual's biography, which incorporates

	both position in the social structure and stage in the life course" (Weigert et al, 1990, p. 50).
"M*ediational means constrain as well as enable action"* As a cultural tool, mediational means provide limitations and empowerment (Wertsch, 1998, p. 38).	The positional nature of identity may lock an individual into a particular form of life or practice. "Selves are committed to roles that are relevant to their identities" (Weigert et al, 1990, p. 52).
"N*ew mediational means transform mediated action"* New cultural tools may facilitate the agent's advancement, thereby introducing a systemic inequality, which alters mediated action (Wetsch, 1998, p. 43).	"Dimensions of self are transformed into meaningful objects as subjective and objective identities at the analytical levels of ego, individual, group, organization, and society" (Weigert et al, 1990). Associated with new practices, social identities may empower or hinder an individual within social institutions (McCall & Simmons, 1978).
"T*he relationship of agents toward mediational means can be characterized in terms of mastery"* Mastery or competence suggests that the agent has identified with the efficient use of cultural tools (Wertsch, 1998, p. 57).	Mastering one social role may lead to an opportunity to assume another. People arrange their social identities in salience hierarchies according to their perceived usefulness at a given time (McCall & Simmons, 1978). "Multiple identities are enacted according to salience hierarchies based on the a priori institutional order, the felt probabilities of success, and the dramaturgical skills of the performers in the situation" (Weigert et al, 1990, p. 47).
"T*he relationship of agents toward mediational means can be characterized in terms of appropriation"* By appropriation, the *active* agent makes the mediational means his/her own (Wertsch, 1998, p. 53).	Social selves form when individuals internalize "institutionalized structures of meaning" such as language and "interpretive procedures" (Weigert et al, 1990, p. 39) Appropriation refers to how an individual negotiates his/her social identities in the dialectic of society (Berger & Luckmann, 1966).
"M*ediational means are often produced for reasons other than to facilitate mediated action"* New cultural tools emerge that are not associated with "conscious decisions"	Identities may be produced in response to emotional issues such as shame (Lynd, 1965). "Self is a multidimensional, reflexive, experiential process involving knowledge

(Wertsch, 1998, p. 59).	and emotion shaped by the individual's roles and social position" (Weigert et al, 1990, p. 42).
"*Mediational means are associated with power and authority"* Power and authority are secured with the cultural tools available in certain settings (Wertsch, 1998, p. 66).	"Meanings are realized – that is, become known and behaviourally real – in mutually oriented responses according to the taken-for-granted structures of society, especially power and trust" (Weigert et al, 1990, p. 36). Exchange resources such as money and education empower some social identities over others (McCall & Simmons, 1978).

In my study, *mediated action* refers to the *strategies*, or ways of doing something, *negotiated* by individual actors in order to stage a particular *role performance*. Lofland (1976) writes "Roles *are* strategies as well as being constructed *of* strategies" (p. 143). For example, 'learner of school mathematics' is a strategic social role in its own right that is associated with many different strategic role performances. An individual's unique "act" forms a *role identity* or *social identity* with respect to a particular *social role* or *identity type*.

Negotiated by the actor's *action-specific strategies*, social identities function as *mediational means*. Wertsch (1991) argues that mediational means, such as social identities, are *activated by action* since they are powerless by themselves (Wertsch, 1991, p. 119). Thus it is the person acting with the mediational means of social identities who is the description of the unit of analysis for my study. In Part II, I use this working theory to articulate my research approach by defining the sample, a system for data collection, and a procedure for data analysis. I also address ethical considerations, as well as case study generalizability and validity.

Main Theoretical Components

Before moving on to Part II, I offer the following condensed account of the main theoretical components that define the interpretive research paradigm with respect to my research:

- Ontology: Subjective Reality. Human reality is socially constructed. Identity is a component of subjective reality, and emerges from the dialectic between the individual and society (Berger & Luckmann, 1966).
- Epistemology: Personal Knowledge. (a) Human knowledge is socially constructed, and socially distributed (Berger & Luckmann, 1966). (b) Truth is established through social interaction, and by means of a consensus.
- Methodology: Select an appropriate unit of analysis. Mediated action is bound to the agent who is the person(s)-acting-with-mediational means (Wertsch, 1991). Mediational means include the semiotic mediation of identity.

My study's purpose is to gather and describe case studies of 'struggling' teenage boys, focusing on their identities, which I assume are mediated by the discursive practices associated with school mathematics and other activities.

Part II: Research Approach

Sample

My research focused on a sample of **seven** struggling teenage boys, but considered the case of one boy at a time. Kennedy (1979) defined single case studies as "*either* (a) studies of single events, *or* (b) disaggregated studies of multiple events" (p. 664). In the second scenario, the researcher "may study more than one case, but study the cases individually, rather than averaging or in other ways pooling data across cases" (Kennedy, 1979, p. 664). Each case of how a struggling teenage boy does school mathematics represented a unique

event. This approach aligned with my intention to produce well-grounded descriptions of each case, organized in accordance with the working theory.

System for Collecting Data

The purpose of this section is to outline the data sources and data collection methods for my case studies:

- Personal Data: I reviewed transcripts, written teacher reports, standardized test scores, and school application materials, which include personal information such as date of birth, location of residence, parental occupations, marital status, etc. Other sources of data include educational testing, and documentation from other schools and programs attended.
- Essay: I asked the students to write a short open-ended essay entitled *My Experience with Math.* I allowed students to use their laptop computer, if they wished, so long as they printed it out immediately afterward. Nevertheless, some students preferred to write the essay using a pencil and paper. The students did not edit their essays or rework them in any way. Students composed their essays in a single sitting within a classroom setting.
- Classroom Observations: Within an interpretive study, the literature stresses the usefulness of data collected from direct observations of the research subjects (Carspecken, 1996; Fetterman, 1998; Thomas, 1993). Broadly speaking, from my perspective as the boys' teacher, my observations focused on the semiotic mediation of identity within the conversations and cultural practices associated with school mathematics. I also experienced firsthand other important details, such as the boys' mathematics progression, which were relevant to their work in the classroom. I

collected notes concerning my students' behaviour, appearance, and comments they made during mathematics lessons.

- Interviews: Each student and I selected a convenient time in which I could interview him. Interviews were exploratory, and were directed at finding out about the student's current and past experience with mathematics, his parent's attitude towards mathematics and careers, and his plans for post-secondary studies and/or future career. I used a digital tape recorder, and uploaded the audio files to my computer. I listened to them on multiple occasions in order to locate the most relevant data with respect to my research topic and questions. I generated a paper and pencil transcript from the audio dialogue, before typing it into a word processing document that served as a cumulative data base for the cases. I organized the data according to its corresponding case. I examined the entire written interview transcript in conjunction with the "winnowing" or separating process (Seidman, 2006, p. 118).

Data Analysis

The data analysis procedure occurred in four phases, and is summarized in the table below:

First Phase	Second Phase	Third Phase	Fourth Phase
Gather and Synthesize: Personal Data Essay Observations Interview	Match Individual Data to Wertsch's (1998) "*Ten basic claims*" about Mediated Action in an Analytical Table	Micro-Analysis: Focusing on one boy at a time, write a brief analysis of what the Analytical Table is saying about that boy's struggle in school mathematics.	Over-arching Synthesis: Link data, analysis, and "*claims"* to the Identity Literature to answer Research Questions

I. In the first phase, I summarized each boy's personal data, synthesized my classroom observations, and identified relevant segments of the interview. With a view towards my research topic and questions, I exercised my judgment as to what observations and interview data were displayed in the body of the paper (Seidman, 2006, p. 119). Shaped as individual profiles, this primary data, along with each boy's essay, appears in Chapter 4 Data Presentation and Analysis. The full interview transcripts appear in the Appendix.

II. In the second phase, I matched excerpts from the individual profile data to Wertsch's (1998) "*Ten basic claims*" about *mediated action*. This involved searching for "connecting threads" within the excerpts that matched the *claims* (Seidman, 2006, p. 125). The results of this analysis are displayed in an analytical table for each case in Chapter 4 Data Presentation and Analysis. Thus the organization of the case studies is driven by the logic of the theoretical framework, with individual case studies demarcated for clear distinction.

III. The third phase of my data analysis was a micro-analysis of the seven case studies, taken one at a time. I used the analytical tables to identify the ways in which each boy struggles with school mathematics. Because he negotiates multiple roles, the tables describe *how* he did school mathematics and other social things, with the focus, of course, on self as learner of mathematics. Related to my research questions, I summarized these findings in a paragraph for each boy, which appears after his analytical table, in Chapter 4 Data Presentation and Analysis.

IV. Phase four *linked the data, analysis, and claims to the boys' mathematical and other identities*. This in combination with the identity literature helped me to answer my four research questions in Chapter 5 Discussion.

My approach aligned with Yin (2003b), who argued it is preferable that data inspection for the purpose of analysis occur in layers, whilst attempting to bring the larger picture into focus. It is also recommended that the discussion about the data take alternative interpretations into consideration. Throughout this detail-laden process, Yin (2003b) emphasized the importance of maintaining focus on the original purpose of the case studies.

Insider's Perspective

My position as the mathematics teacher of my research subjects gave me an insider's perspective. I also had the opportunity to get to know my research subjects personally, both inside and outside the mathematics classroom, which is a typical feature of being a faculty member at a residential school. My own authority and knowledge likely appear in the data analysis. Nevertheless, the advantages of being an insider are frequently tempered by the risks of developing preconceived notions about one's students.

Ethical Considerations

Whilst collecting case study data, it was ethically essential for me to obtain permission to interview potential research subjects and to use their personal information. There was no compulsion for students to participate in my study, and those that did participate had the right to withdraw at any stage. Each research subject also understood the nature, aims, and purpose of my study. All information revealed by the research participant was used solely for the purpose of the research project, which includes the sharing of information with other researchers through various publications. To protect their privacy, I used pseudonyms to refer to my research subjects, as well as to geographic details about the location of their

homes, former schools, and programs. The name of my school in which I conducted the research is obscured.

On the same note, my project was not so unduly emphasized as to detract from my students' studies. Fetterman (1998) stresses the importance of caring for our research subjects and our relationships with them by doing careful work:

> The single most important guide to protecting participants is doing good work. An honest and thorough job presented in a clear and compelling manner will serve the participant well. … The researcher must pursue each interview, observation, and analytical task with diligence. A lack of rigour or energy at any stage will diminish the quality and accuracy of the final product. Similarly, any decay in human relations during fieldwork will have an adverse impact on the ethnography or ethnographically informed report. Any of these weaknesses can endanger the group under study through misrepresentation and misunderstanding. (Fetterman, 1998, p. 145)

Descriptive case studies require a high level of commitment on the part of the researcher. The strength of the evidence, which is of utmost importance to the project's success, is dependent upon rigorous work (Kennedy, 1979). Since I am the teacher, I have an added responsibility to maintain the status quo and be as unobtrusive to the learning environment as possible. No major changes to the participants' mathematics curriculum resulted from carrying out my study. Nevertheless, I gained valuable insight in the course of my research, which will ultimately enhance my students' program.

Case Study Approach

Before going on to discuss generalizability and reliability, I need to offer a clear picture of the nature of the case study approach, and how I appropriated it for my research. The design of my case studies was based on the working theory of Wertsch's (1998) "*Ten basic claims*" that characterized mediated action (p. 25). The term 'theory' refers to one or more

descriptive theories that are synthesized in order to cover "the scope and depth of the object (case) being described" (Yin, 2003a, p. 23). Developed and presented before gathering the data, a theory draws from multiple sources and is thus an eclectic assemblage of theoretical components needed all together to describe the case or the situation under study.

Descriptive theories help to enforce boundaries. *Boundaries* refer to the "distinction between the phenomenon being studied and its context" (Yin, 2003b, p. 162). Boundaries serve as theoretical walls that prevent the case studies from becoming oversized and fragmented. In short, the descriptive theories, in my case study approach, worked in conjunction with the research questions to organize and maintain the focus of the effort.

Yin (2003b) articulated a succinct definition of a case study, which I used to put my research endeavour into perspective:

1. *A case study is an empirical inquiry that*
    - investigates a contemporary phenomenon within its real-life context, especially when
    - the boundaries between phenomenon and context are not clearly evident.
2. *The case study inquiry*
    - copes with the technically distinctive situation in which there will be many more variables of interest than data points, and as one result
    - relies on multiple sources of evidence, with data needing to converge in a triangulating fashion, and as another result
    - benefits from the prior development of theoretical propositions to guide data collection and analysis.

    (Yin, 2003b, pp. 13-14)

For my study, the contemporary phenomenon was struggling teenage boys doing school mathematics. The real-life context was a small residential high school for boys. Since the school seeks to enrol boys who have struggled, the boundaries between the phenomenon and the context were blurred. The context's (school's) mission of serving struggling

students creates a technically distinctive situation that challenges traditional school norms. Nevertheless, the context contributed a diverse sample of struggling teenage boys, who provided a great deal of data from multiple sources. (Data triangulation is discussed along with validity in a later section.)

Yin (2003b) outlines three components of case study completeness: (1) attention to the boundaries, (2) a meticulous effort to collect evidence, (3) a demonstration that there were no time or resource constraints (pp. 162-163). The researcher must attempt to collect a comprehensive set of important details pertaining to the case. This effort cannot be rushed because of schedule limitations, or abruptly terminated because of deficient resources. Excellent case studies require a consistent, detail-oriented effort.

Generalizability

Without the whole picture in mind, focused through the lens of the research questions and descriptive theory, the data presents only isolated fragments. However, even with the finest effort to pull the data together, the extrapolation of a case study is subject to limits:

> Case studies, like experiments, are generalizable to theoretical propositions and not populations or universes. (Yin, 2003b, p. 10)

The researcher cannot make sweeping generalizations about the phenomenon under scrutiny by means of a case study. The researcher can, however, generalize the case studies to the descriptive theory developed beforehand, which is the theoretical framework of the case.

It is more important for the case studies to demonstrate *strong evidence*, than to produce any *general outcome* (Kennedy, 1979). Another important point about generalization is that

it is not a function of the number of units observed. Increasing the number of individuals in a study does not increase its generalizability (Kennedy, 1979).

> More important are the *kinds* of units observed, that is, the range of characteristics of the units investigated and the range of conditions under which observation occurred. The range of characteristics included in a sample increases the range of population characteristics to which generalization is possible. Thus, generalizations may vary in the range of population characteristics encompassed as well as in the strength of confidence one has in the generalization argument.
> (Kennedy, 1979, p. 665)

Whilst maintaining focus on the purpose of the research, the richness and variety of the case study data are more important than the quantity. The *variety of characteristics* included in the research data facilitates a more comprehensive generalization process. In the generalization process, it is important to consider the evidence from different perspectives, and also to include the evidence that may not support the prevailing version of the analysis.

Validity

Validity in single-case study research is established by executing tests or checks on the data collection means, as well as on the research design. Yin (2003b) recommends three tests for descriptive case studies: (1) construct validity, (2) external validity, and (3) reliability, which are supported by Yin's (2003b) tactics that appear in the brackets below:

- *Construct validity*: establishing correct operational measures for the concepts being studied [Use multiple sources of evidence; establish chain of evidence]
- *External validity*: establishing the domain to which a study's findings can be generalized [Use theory in single-case studies]
- *Reliability*: demonstrating that the operations of a study—such as the data collection procedures—can be repeated, with the same results [Use case study protocol]
  (Yin, 2003b, p. 34)

External validity pertains to the boundaries of the research design. Kennedy (1979) argues that "strength of external validity" is "strength of generalizability" (p. 665). Yin (2003a) asserts that descriptive/exploratory case studies cannot establish causal relationships, but can only be generalized to the theoretical framework. External validity is met by defining the boundaries of this domain.

Construct validity and reliability occur in conjunction with data collection. Construct validity aligns methodology and method. Matching "the conceptual goals of the research" to "its methodological means" helps to avoid the problem of construct validity, which occurs when what is actually being studied is different from what the researcher intended (Matusov, 2007, p. 314).

Yin (2003b) notes that reliability refers to doing the case study again, rather than replicating the case study. This distinction is important because *reliability aims at consistent procedures*, with a view towards accuracy and unbiased work (Yin, 2003b). Qualitative data-gathering methods are appropriate for the descriptive case study approach, including inspection of student records, conducting interviews, and gathering students' work. As I have previously discussed, these methods facilitated rich descriptions of the cases under study.

Given the qualitative nature of the collected data, I also consider "ethnographic validity" in my study (Fetterman, 1998). Data triangulation is accomplished by checking to see if various sources of data, such as student files and information gleaned from interviews, agree with one another. Identifying possible discrepancies between the observations in my

notes and what the research subject said is another example of ensuring ethnographic validity. Interviews should avoid leading questions, which may prompt the research subject to offer approval-seeking responses (Carspecken, 1996).

According to Fetterman (1998), finding patterns in the data indicates "ethnographic reliability." However, I must emphasize that *no* general conclusion can be drawn from analyzing these patterns. The data is shaped into a rich description that depends upon the researcher's perception:

> How we "hear" our data as they speak to us, and how we translate what we have heard into a set of messages for an audience, gives the researcher the power to define and transmit "reality." As a consequence, the discourse in which we write our results is as important as the language of the texts of the field notes that we analyze. (Thomas, 1993, p. 45)

Since I am the research subjects' mathematics teacher, my writing style undoubtedly communicates my personal involvement with them, and my concern for their best interests. In that respect, my writing up the results makes me a participant in the research process as well.

Concerning personal relationships with research subjects, Thomas (1993) cautions the researcher against becoming partial or prejudiced:

> Sometimes we become so enmeshed in our fieldwork that we join the "other side" … Or we become so disillusioned with the subjects that we become cynical, patronizing, or hostile … This need not be a problem if we are aware of how the changes in perspective shape our results, so that we avoid either romanticizing or dismissing our subjects. (p. 46)

This indicates that some aspects of research may be subject to the frame of mind of the researcher. Based on my experience, I have learned that struggling students can exhibit a

wide range of attitudes. Interacting with them on a daily basis can be emotionally challenging. Thus, throughout my project, I focused on maintaining wellness and a balanced perspective.

CHAPTER 4

DATA PRESENTATION AND ANALYSIS

Introduction

This chapter presents case studies of the mathematical and other identities of 'struggling' teenage boys, which focus on the following research questions:

1. How does doing school mathematics mediate the identities of 'struggling' teenage boys?
2. How do 'struggling' teenage boys mediate their identities in school mathematics?
3. How do 'struggling' teenage boys mediate their identities in school mathematics and their identities shaped by other social practices?
4. How do the boys' past experiences mediate their present identities in school mathematics?

After gathering the case studies, I performed the data inspection in layers, starting from the complete personal data, observations, and interview transcripts (Yin, 2003b). My "winnowing" process aimed at identifying personal data, selected observations, and interview segments that illuminated my research topic and questions (Seidman, 2006, p. 118). I exercised my best judgement in carrying out this endeavour (Seidman, 2006, p. 119). After deciding what personal data, observations, and interview segments to display, I compiled the individual profiles included in this chapter.

Because I wish to present each boy's case as transparently as possible, individual case studies contain an outline of the boy's personal profile, which includes his age, grade, geographic location, relevant family details, educational history, and school mathematics progression, as well as his outside interests and hobbies. This is followed by a piece of his

writing, selected classroom observations, and segments of the interview. The full interview transcript is included in the Appendix.

I scanned each individual profile displayed in order to identify excerpts that matched Wertsch's (1998) "*Ten basic claims*" about mediated action. I present the result of my effort in a data analysis table. Concluding each case, a prose analysis relates the analytical tables to my research questions, and provides a brief verbal summary about that boy's struggle in school mathematics. Delineated by this arrangement, my seven case studies of struggling teenage boys are Tyler, Adam, Raymond, Edward, James, Arthur, and Jack. The boys range in age from sixteen to eighteen, and represent a variety of geographic locations and family backgrounds. The chapter concludes with an overview comment that reflects upon the case studies in relation to my research questions.

Tyler

Personal Data

- Age 17.5
- Grade 12 (High School Senior)
- Grew up in an upscale community in the Northeast (U.S.)
- Father is a lawyer and mother is a homemaker
- Tyler is the eldest of two male children
- Scholastic Aptitude Test (SAT I) taken in the fall of his Senior (Grade 12) year:
  Critical Reading (600) – **79th** National Percentile
  Math (350) – **7th** National Percentile
- School Attendance & Math Progression:
  Grades kindergarten through eighth - local public schools, Arithmetic to Pre-Algebra;
  Grade 9 – therapeutic boarding school, Pre-Algebra;

Grade 10 – small boarding school, Algebra and Geometry;

Grade 11 – local public school for three months, then returns to small boarding school, no math taken this year;

Grade 12 – small boarding school, Business/Consumer Math.

- Tyler is currently studying Business/Consumer Math with four other boys.
- Tyler is a healthy, physically-fit young man who enjoys kick-boxing as a martial art.

Student Essay

My experience with math

Math has always been like magic to me. Like all thought it seems to arise from the darkness, bring understanding and then fade back into darkness. I have no idea how a human mind could create something like an algebraic equation without just using trial and error. An algebraic equation I recognize as nothing more than a truth with no plausible explanation.

My experience with math started before preschool. For as long as I can remember I have loved legos and what they allowed me to create. My childish mind could not allow me to create anything that was not perfectly symmetrical and even coloured. Even then my mind wanted to abide by the concept of symmetry that allows for all logic. Before preschool I had watched all the national geographic movies in the library and was fascinated by the beauty and symmetry of the natural world.

Things that did not make sense to me frustrated me to no end. As a child I did not have very refined concepts of morals, which made the consequences of my parents seem outlandish. THEY CAUSED ME TO GO APE SHIT. If I was Stephen Hawking trying to explain an astronomical anomaly, I would shoot myself.

My academic experience of math and logic went perfectly smooth up until high school. Addition and subtraction were concepts that I could dissect, understand and work with. In second grade I started working with multiplication. Although later I would be able to take that apart too, I just memorized the processes. The only difficulty came about when I tried to do algebra. Although an algebraic equation is truth, I can't understand why it is truth. The best I can do is keep the equation in my arsenal of magic. Like fire to a cave man.

My inability to understand algebra creates a huge aversion to it. I can't get myself to memorize things that have no meaning to me. Because I don't actually understand the mechanics of algebraic equations I just forget them anyway. I feel that as long as the magic

is written down in a book somewhere I can look it up if I ever need it.

I recognize that math is essentially reading the laws of the universe. If God will ever be found through science he will be the ultimate strain of logic or the perfect mathematical truth. If we had that then I'm sure that the universe would be as predictable to us as the answer to 1 + 1.

Classroom Observations

During a mathematics lesson, Tyler made this comment when I asked members of the class to complete a basic skills worksheet in order to practice percentages:

> T: Doing something so simple is wasting my life.

In the Business/Consumer Math class, Tyler put his head down on the classroom table during a practical discussion about how one keeps track of personal expenses or manages a checkbook/checking account. On one occasion, I asked the class to estimate their personal expenses, if they were living on their own. Next to the word 'Rent', Tyler wrote, "Hopefully none".

In another exercise, I asked the Business/Consumer Math class to select an occupation of interest, and research how much an individual pursuing this career is compensated. Tyler picked the occupation of 'landscaper' and reported that a landscaper earned $8.00 per hour. Tyler said that he worked as a landscaper during the previous summer.

Interview

Tyler summarizes his difficult experience with school mathematics:

> T: I had it all figured out until algebra, which is basically like learning another language.

Tyler talks about his parent's experience with school mathematics:

> M: How did your dad like math?

T: He wasn't very good at it.

With prompting, Tyler recalled a story that his father liked to tell about nearly failing a mathematics exam:

T: One of his professors put a minus sign that extended all the way across the paper on his D-minus.

I asked Tyler about his mother's experience with school math:

M: What about your mom?
T: I don't know anything about her academics. She's pretty intelligent, so I'm sure she could figure it out.

Tyler discussed his previous experience with math:

M: Can you remember any math teacher that you had before me?
T: ... Mr. Mellon in eight and seventh grade. Before that I think that math was just something that your one teacher taught you.

Tyler described Mr. Mellon, his junior high school math teacher:

T: He was a pretty funny guy and kind of like a computer geek type of guy, except with a sense of humour (pause) that targeted those that were not very good at math.

Tyler tells me that Einstein is an example of someone who is good at math:

M: Describe a person who is good at math.
T: Einstein, he is pretty much the classic example, right? He's good at math. Einstein's good at math.

Data Analysis

The table below presents Tyler's data in accordance with Wertsch's (1998) "*Ten basic claims*" about mediated action:

Wertsch's (1998) "*Ten basic claims*" (p. 25).	**Tyler's data:**
Mediated action is characterized by an irreducible tension between agent and mediational means	An irreducible tension is evident in Tyler's standardized test scores, which were above average in Critical Reading (**79th** National Percentile), and significantly below average in Math (**7th** National Percentile). (Personal)

	Currently a Senior (Grade 12), Tyler has attended three different high schools. Tyler did not study math in Grade 11 during the three months he attended public school, or when he returned to the small boarding school (Personal). These discontinuities in school placement, and in the mathematics curriculum, create a structural tension in Tyler's path through secondary education.
M*ediational means are material*	The material quality of mediational means is evident when Tyler describes his former math teacher as "a computer geek type of guy" (Interview). Posture, as a mediational means, is material. During math class, Tyler put his head down on the table during a practical discussion about how one keeps track of personal expenses or manages a checkbook/checking account (Observation). Cultural practices, involving the body, are also material. Tyler is a healthy, physically-fit young man who enjoys kick-boxing as a martial art (Personal).
M*ediated action typically has multiple simultaneous goals*	Tyler's resistance to parental rules parallels his self-professed refusal to do complex mathematical tasks. He writes, "As a child I did not have very refined concepts of morals, which made the consequences of my parents seem outlandish" (Essay). In the same paragraph, Tyler asserts that it would be impossible for him to work like Stephen Hawking, solving problems in astronomy using mathematics (Essay). Tyler wishes to avoid the frustration. "Things that did not make sense to me frustrated me to no end" (Essay). Tyler suggests that his goal is to keep algebraic equations in his "arsenal of magic" (i.e., if he knows where to find such "tools", he does not have to memorize them in order to be able to use them). "I feel that as long as

	the magic is written down in a book somewhere I can look it up if I ever need it" (Essay). Another implied goal is to focus his energy primarily on things that have personal meaning to him: "I can't get myself to memorize things that have no meaning to me" (Essay). These are examples of multiple simultaneous goals.
M*ediated action is situated on one or more developmental paths*	In his essay, Tyler juxtaposes his experience as a learner of mathematics with his social development from preschool to the present time. This suggests several developmental paths.
M*ediational means constrain as well as enable action*	*Constrained* by Tyler's lack of understanding: "I can't get myself to memorize things that have no meaning to me" (Essay). Tyler writes, "My inability to understand algebra creates a huge aversion to it" (Essay). *Constrained* by Tyler's lack of interest: "Doing something so simple is wasting my life" (Observation). *Enabled* by Tyler's sense of wonder: Tyler admits that he is "fascinated by the beauty and symmetry of the natural world" (Essay). *Enabled* by Tyler's expressed need for order and control: "My childish mind could not allow me to create anything that was not perfectly symmetrical and even coloured" (Essay).
N*ew mediational means transform mediated action*	Tyler is age 17.5 years and in his final year of high school (Personal). In Business/Consumer Math class, Tyler displays disinterest in applying math to real life situations, such as monitoring personal expenses (Observation). When estimating expenses, he writes, "Hopefully none" next to the word 'Rent' (Observation).

	In a classroom exercise about compensation, Tyler selects 'landscaper', an occupation he did as a summer job (Observation). Tyler is reticent about new mediational means, which correspond to his transformation into an emerging-adult.
T*he relationship of agents toward mediational means can be characterized in terms of mastery*	Mastery is evident when Tyler asserts, "Addition and subtraction were concepts that I could dissect, understand and work with" (Essay). Lack of mastery is evident when Tyler says, "I had it all figured out until algebra, which is basically like learning another language" (Interview). Tyler comments on mastery with respect to others: "Einstein's good at math" (Tyler, Interview). Tyler thinks that his mother is "pretty intelligent" and thus he thinks, probably competent in school mathematics, as he said "she could figure it out" (Interview).
T*he relationship of agents toward mediational means can be characterized in terms of appropriation*	Despite his difficulties, Tyler articulates his workable relationship with school mathematics: "I feel that as long as the magic is written down in a book somewhere I can look it up if ever I need it" (Essay). "The best I can do is keep the equation in my arsenal of magic. Like fire to a cave man" (Essay). These statements characterize how Tyler has individually appropriated school mathematics.
M*ediational means are often produced for reasons other than to facilitate mediated action*	Embarrassment may be characterized as an emotion, which is produced for reasons other than to facilitate mediated action. Tyler's comments depict the embarrassment of not being good at math: Tyler remembered that Mr. Mellon's sense of humour was targeted at people who were not good at math (Interview).

	Tyler reported that his father was not good at math (Interview). Tyler tells his father's story of barely passing a mathematics exam. The grade his father received was D-minus with a "minus sign that extended all the way across the paper" (Interview).
Mediational means are associated with power and authority	Tyler writes that, "Math has always been like magic to me" (Essay). God, according to Tyler, is the "ultimate strain of logic or the perfect mathematical truth" (Essay). Tyler asserts that if we had perfect mathematical truth, "I'm sure that the universe would be as predictable to us as the answer to 1 + 1" (Essay). Tyler associates mathematics with sources of power and authority, such as magic, God, and the universe.

This data table indicated how Tyler, in both words and gestures, mediated his mathematical identity in his active resistance towards doing math, which paralleled his conflicts with his parents and his discontinuous school attendance. Suggesting a conflict between his subjective and objective identities, Tyler's frustration may be linked to the apparent incompatibility between his intellectual persona and his role as a struggling math student. Mediating his present mathematical identity in his past experiences, Tyler recalled his embarrassment at not being good at math in Mr. Mellon's eighth grade class. The position of underdog is echoed in the story Tyler recalled about how his father failed a math exam. Nevertheless, in appropriating school mathematics, Tyler was thoughtful about his mathematical shortcomings, as he reported that if he should be faced with a math-related dilemma, he would simply consult a reference. Though it was within his abilities, Tyler stated that he was uninterested in doing the practical math associated with real life activities, such as tracking personal expenses in Business/Consumer Math class. Rather, in

mediating his identity within school mathematics, he preferred to align himself with great minds such as Einstein and Stephen Hawking whilst speculating about lofty mathematical truths. Mediating his identities in other practices as well, Tyler's words about magic suggested that he was motivated by a genuine sense of wonder, as he took the opportunity to express his fascination with how mathematics revealed the mysteries of the physical world.

Adam

Personal Data

- Age 16
- Grade 10 (High School Sophomore)
- Grew up in various locations in the United States
- Father is a professional and mother is a homemaker
- Adam is the youngest of two male children (Adopted)
- School Attendance & Math Progression:
  Grades kindergarten through eighth – private day schools, Arithmetic to Pre-Algebra;
  Grade 9 – private day school, Pre-Algebra;
  Grade 10 – traditional boarding school for two months, Algebra; therapeutic wilderness program for one month; small boarding school for the remainder of the school year, Algebra and Geometry.
- Adam is currently studying Algebra and Geometry with two other boys.
- Adam is a healthy young man who enjoys anaerobic weight training, and playing the guitar.

Student Essay

My Experience With Math

The first time I ever started to study math, was in first grade. It was your basic addition and

subtraction, but it opened up a new world for me. I have never really been a big fan of math, or doing math for that matter, but I know that it would be worth it in the long run. I have always wanted to be a mechanic or engineer of some sort, so math would be extremely important. I have taken math courses throughout my whole life. I find them to be very time consuming and boring. I don't really like things that take up a lot of my time.

Math is something that I would like to expand on because it would allow me to have more possibilities later on in life. My favourite part of math would have to be geometry. I say this because it's something that I'm interested, and because I've liked every teacher that taught me it.

Classroom Observations

In the classroom, Adam is consistently attentive. He steadily attempts practice problems, and participates in class discussions. Adam made an excellent effort on his winter term exam.

Interview

As I am starting my tape recorder, Adam is telling me that he does not like math.

> M: Tell me why don't you like math, Adam. You just said that you didn't like it.
> A: I guess I don't really like it because it's really time consuming, and I mean, being a teenager myself, I guess I don't really have the patience to do it (pause) and I've never really been good at it. I guess it will be something that I'd like to learn more how to do, and do it more frequently, so that I can become better at it.
>
> M: Do you see yourself using math in a potential career?
> A: Oh definitely, probably a field of mechanics like engineering, something like that, something where I could use my hands.
> M: Is that what interests you?
> A: Yes, building things.

Adam agrees that he sees himself using math after high school, and thus he would like to improve his competency.

> A: So I'd like to get better at it, but things take time, especially math.

Adam said that he liked geometry more than algebra "because it has to do with shapes" and that it is "fun" to solve problems involving angles.

Data Analysis

The table below presents Adam's data in accordance with Wertsch's (1998) "*Ten basic claims*" about mediated action:

Wertsch's (1998) "*Ten basic claims*" (p. 25).	**Adam's Data**
M*ediated action is characterized by an irreducible tension between agent and mediational means*	Adam is a Sophomore (grade 10), who has attended three different high schools, and a therapeutic wilderness program (Personal). An irreducible tension is evident in these breaks with respect to school mathematics.
M*ediational means are material*	Material characteristics emerge from Adam's wish to use his hands, building things, in a future vocation (Interview). They are also reflected in Adam's interest in anaerobic weight training, and playing the guitar (Personal).
M*ediated action typically has multiple simultaneous goals*	Multiple and simultaneous goals are revealed in Adam's long-term aspirations, and current classroom performances: "I have never really been a big fan of math, or doing math for that matter, but I know that it would be worth it in the long run" (Essay). Because Adam sees himself using math after high school, he would like to improve his competency (Interview). In the classroom, Adam is consistently attentive. He steadily attempts practice problems, and participates in class discussions. Adam made an excellent effort on his winter term exam. (Observation). Adam implies that he wishes to avoid time-consuming and boring tasks (Essay).
M*ediated action is situated on one or more developmental paths*	Adam attributes his lack of patience in doing math to being a "teenager"

	(Interview). By referring to both 'math' and 'teenager', Adam illuminates several developmental paths.
M*ediational means constrain as well as enable action*	*Constrained* by Adam's lack of patience: "I have taken math courses throughout my whole life. I find them to be very time consuming and boring. I don't really like things that take up a lot of my time" (Essay). *Constrained* by Adam's lack of confidence: "I've never really been good at it" (Interview). *Enabled* by Adam's interest in mechanics and engineering: "I have always wanted to be a mechanic or engineer of some sort, so math would be extremely important" (Essay). *Enabled* by Adam's interest in Geometry, and positive relationship with his teacher: "I say this because it's something that I'm interested, and because I've liked every teacher that taught me it" (Essay).
N*ew mediational means transform mediated action*	Adam recalls a transformation associated with learning arithmetic: "The first time I ever started to study math, was in first grade. It was your basic addition and subtraction, but it opened up a new world for me" (Essay).
T*he relationship of agents toward mediational means can be characterized in terms of mastery*	Adam's concern about mastery is evident in these comments: "I guess it will be something that I'd like to learn more how to do, and do it more frequently, so that I can become better at it" (Interview). "I'd like to get better at it, but things take time, especially math" (Interview).
T*he relationship of agents toward mediational means can be characterized in terms of appropriation*	"My favourite part of math would have to be geometry" (Essay). Adam thinks it is "fun" to solve problems involving angles (Interview).

	These are evidence of how Adam has appropriated school mathematics.
M*ediational means are often produced for reasons other than to facilitate mediated action*	Feelings of failure are produced for reasons other than to facilitate mediated action: "I've never really been good at it" (Interview).
M*ediational means are associated with power and authority*	Adam's enhanced career opportunities are associated with power and authority: "Math is something that I would like to expand on because it would allow me to have more possibilities later on in life" (Essay).

Indicating how doing school mathematics mediated his mathematical identity, Adam said that solving geometry problems was an enjoyable activity, especially when he liked his teacher. Despite his breaks in his math progression, he remembered how learning addition and subtraction opened up a new world for him. Adam admitted that he sometimes found doing math boring, a statement that pointed towards the way he mediated his identity within school mathematics. Illuminating his emotions, Adam sometimes reflected upon his feelings of failure. This attitude was undoubtedly based on past experiences with school mathematics. The data table showed that Adam attributed his unwillingness to do time-consuming and boring tasks in school mathematics to being a teenager, which suggested several developmental paths. Compliant and attentive, Adam attempted to improve his math skills. That Adam was primarily motivated by his desire to pursue a technical career that would allow him to work with his hands illustrated how he mediated his mathematical identities in conjunction with various practices. Empowered by mathematical knowledge as an exchange resource, Adam stated that mastering math was very important to his future success. Enhancing his career prospects was a dominant goal in Adam's approach to school mathematics.

Raymond

Personal Data

- Age 16
- Grade 10 (High School Sophomore)
- Grew up in the southern United States
- Father is a professional. Mother is a business owner. (Divorced)
- Raymond is the youngest of two male children
- School Attendance & Math Progression:

  Grades kindergarten through eighth – public schools, Arithmetic to Algebra, Gifted Program (Grades 3-7);

  Grade 9 – public high school, Geometry (failed), therapeutic wilderness program for one month during the summer;

  Grade 10 – small boarding school, Algebra II and Geometry.
- Raymond is currently studying Algebra II and Geometry.
- Raymond is an athletic young man who enjoys a variety of sports.

Student Essay

I have always enjoyed doing math. I feel that math is by far the most important subject that you can learn. I would like to major in business when I get older. In business, math helps a lot. Even when you go to a store to buy something, you use math to count the money you get back. I think that math controls the world, especially with money. That is how I feel about math.

Classroom Observations

Raymond initiates competition with the other boys in his math class.

During math lessons, Raymond is sometimes disruptive. When this occurs, his actions may be characterized as humorous and/or attention-seeking.

Interview

Raymond's comments reveal that he likes math, and that he is good at it, although he avoids studying it outside the classroom:

> R: I'm good at math so I kind of like it.
>
> R: I don't really study it. I feel that it just comes to my head easily and I don't study that much at home. I just felt like I knew how to do it. Numbers come easy to me.
>
> R: In second grade my mom realized that I was really smart so she got me tested for a gifted program, which is an advanced program. I got like a 97 in math and 92 in reading and so I moved to gifted in third grade and just stayed with advanced classes until 7th grade.

Raymond discussed math in conjunction with his future:

> M: Do you think that math is something that you would like to continue to study?
> R: Yes, it will be good for me in the long run, I think, to know math.
>
> M: Is there any particular career that you are interested in?
> R: Business, I'd like to work in something to do with business with my brother.

Raymond reports that his brother, who is a college business major, is "really good at math." (Raymond said his best friend is really good at math too.) He tells me that a friend of a family member has invited his brother to join a successful business.

> R: You need to know a lot of math to have a business.

I asked Raymond to comment on his parent's experience with math:

> M: Did your parents like math?
> R: … I don't think that either of my parents were that good at math.

Raymond associates math with consumer activities:

> M: So what do you think knowing math enables you to do?
> R: When you buy stuff in stores they can rip you off. They can give you the wrong amount of money and if you know math, you realize – *wait*, this is not the right amount of change, which for some reason I always think about when I buy something. I never just take the money and just walk out. I always look at it, count it, and realize how much money I paid for it.

Raymond distinguishes between his experiences with algebra versus geometry:

> R: I like Algebra, I'm good at algebra. I'm pretty good at geometry too, if I just pay attention to it.

Data Analysis

The table below presents Raymond's data in accordance with Wertsch's (1998) "*Ten basic claims*" about mediated action:

Wertsch's (1998) "*Ten basic claims*" (p. 25).	**Raymond's Data**
Mediated action is characterized by an irreducible tension between agent and mediational means	Raymond is a Sophomore (Grade 10) who has attended two different high schools and a therapeutic wilderness program. Though he studied math at an advanced level in elementary/middle school, he failed Geometry in Grade 9 (Personal). An irreducible tension is evident in Raymond's inconsistent math performance at his former schools.
Mediational means are material	The material nature of mediational means is revealed by the following: "Even when you go to a store to buy something, you use math to count the money you get back" (Essay). During math lessons, Raymond is sometimes disruptive. When this occurs, his actions may be characterized as humorous and/or attention-seeking (Observation). Material qualities are suggested by Raymond's athleticism and enjoyment of a variety of sports (Personal).
Mediated action typically has multiple simultaneous goals	Raymond reveals multiple and simultaneous goals: "Yes, it will be good for me in the long run, I think, to know math" (Interview). "I would like to major in business when I get older" (Essay). "Business, I'd like to work in something to do with business with my brother" (Interview).
Mediated action is situated on one or more	In addition to his personal history, Raymond

developmental paths	discusses math, and business, in conjunction with family and friends. This is evidence of several developmental paths (Interview).
M*ediational means constrain as well as enable action*	*Constrained* by Raymond's lack of consistent effort: "I don't really study it. I feel that it just comes to my head easily and I don't study that much at home" (Interview). *Constrained* by Raymond's lack of consistent attention: "I'm pretty good at geometry too, if I just pay attention to it" (Interview). *Enabled* by Raymond's enjoyment of doing math, and its importance to him: "I have always enjoyed doing math. I feel that math is by far the most important subject that you can learn." (Essay) *Enabled* by Raymond's interest in business: "You need to know a lot of math to have a business" (Interview).
N*ew mediational means transform mediated action*	Raymond tells how he transformed to "gifted" status: "In second grade my mom realized that I was really smart so she got me tested for a gifted program, which is an advance program. I got like a 97 in math and 92 in reading and so I moved to gifted in third grade and just stayed with advanced classes until 7th grade" (Interview).
T*he relationship of agents toward mediational means can be characterized in terms of mastery*	Mastery is evident when Raymond asserts: "I'm good at math so I kind of like it" (Interview). "Numbers come easy to me" (Interview). "I like Algebra, I'm good at algebra" (Interview). Raymond comments on the mastery of others: Raymond reports that his brother, who is a college business major, is "really good at math" (Interview). "I don't think that either of my parents were that good at math" (Interview).

T*he relationship of agents toward mediational means can be characterized in terms of appropriation*	Appropriation is described by Raymond's comments: "When you buy stuff in stores they can rip you off. They can give you the wrong amount of money and if you know math, you realize – *wait*, this is not the right amount of change, which for some reason I always think about when I buy something. I never just take the money and just walk out. I always look at it, count it, and realize how much money I paid for it" (Interview).
M*ediational means are often produced for reasons other than to facilitate mediated action*	Feelings of self-confidence are produced for reasons other than to facilitate mediated action: "I just felt like I knew how to do it" (Interview).
M*ediational means are associated with power and authority*	Raymond's initiation of competition with the other boys in his math class is associated with power and authority (Observation). Raymond associates math with power and authority: "I think that math controls the world, especially with money" (Essay).

As shown in the data table, Raymond reported that because of his high test scores, he was given "gifted" status in the second grade, which allowed him to study math at an advanced level. This illustrated how doing school mathematics mediated his identity. He remained confident in his innate math ability, even though he had failed geometry in the ninth grade, his previous school year. Mediating his identity in mastery of school mathematics, he attributed his shortcomings to his lack of study time and his inconsistent attention to detail. Raymond's frustration with math stemmed from his unwillingness to do the amount of work necessary, outside of class, in order to earn a good grade. He was reluctant to invest independent study time, but he had a solid opinion that learning math would likely benefit his future career in business, which suggested how he mediated his identities with regard to

other practices. Raymond also stressed the importance of the relationship between math and money, something that he reflected upon in his everyday commerce, in which his main objective was not to be cheated by a shopkeeper. Suggesting several developmental paths, Raymond claimed membership in a close-knit group, consisting of his brother and his best friend, who all did well in math. His assertion indicated how his past experiences mediated his present identity in school mathematics. He also recounted how his family's social network supported his brother's success as a business major by offering him employment. Communicating his identity with material means, Raymond was socially gregarious in stirring up competition with the other boys in his class.

Edward

Personal Data

- Age 18
- Grade 12 (High School Senior)
- Grew up in the southern United States
- Father is an independent investor. Mother is a technology administrator. (Divorced)
- Edward is the younger of two children.
- Scholastic Aptitude Test (SAT I) taken in the fall of his Senior (Grade 12) year:
  Critical Reading (550) – **52nd** National Percentile
  Math (570) – **51st** National Percentile
- School Attendance & Math Progression:
  Grades kindergarten through eighth – public schools, Arithmetic to Pre-Algebra;
  Grade 9 through 11 – public school, Algebra I, Geometry, and Algebra II (failed);
  Grade 12 – small boarding school, Algebra II, Trigonometry, and Advanced Algebra.
- Edward is currently studying Advanced Algebra.
- Edward enjoys surfing, snowboarding, and doing yoga.
- Edward volunteers at a marine research laboratory.

Student Essay

My Experience in Math

My experience with math reaches back to the very beginnings of my childhood. I started learning math probably in pre-school, although I cannot remember exactly because I was so young. I remember second grade I started learning the times tables and in third moved up to simple division. When I was in Fourth grade I was considered especially smart and once a week went with a few other students to learn deeper studies. When I was in sixth grade I was a part of the advanced math class, but due to troubles at home, my grades dropped severely. This continued throughout the rest of my school career to the point where I am today. Because of my troubles at home, my mind was always focused on something else, and never what was being taught in the class room. I never handed in any homework, and would sleep the majority of every class, but still managed to make A's on most of the tests. All academic work including math has always come so easy to me that I don't even bother wasting my time trying it when I have bigger things to worry about. There has only been a few times in my math career that I actually learned something from the teacher. All of my knowledge came from reading it out of the text book or getting it taught to me by someone like my sister. Math is a very important part of my life considering I plan on becoming a marine scientist. But no matter what path life takes me down I will always be using math to my benefit.

Classroom Observations

During a math lesson, with my permission, Edward called his father on his cell phone to discuss a math-related disagreement. Enabling the 'speaker' function on the cell phone, Edward told the story of going to a restaurant, over school break, and being asked by his father to calculate the tip (gratuity). Edward asserted that a roughly-estimated tip was sufficient, whereas his father expected him to calculate the exact amount. I assured his father that Edward, who is studying advanced algebra, knew how to exactly calculate percentages in the classroom:

M: Does it carry over into real life?
E: Depends on if I feel like it.
F: I want you to feel like it every time (via cell phone).

Interview

Edward summarizes his earlier experiences with school mathematics:

E: I did well when I tried. I mean, I came out with Bs and Cs when I decided I wanted to pay attention in class and do the work, but I also came out with some Fs and that's when I just wanted to sleep and do crossword puzzles and stuff. So it kind of differed on my mood for that quarter or semester.

Edward said he prefers doing math that is useful in solving problems. He would like to study science and pursue a scientific career. Edward asserts that "science and math cohere, and go hand in hand." Nevertheless, he is reluctant to study any more math in college than he absolutely needs:

E: I'm going to try and get away with doing as less math as possible.

At the lab where he volunteers, under the supervision of a scientist, Edward conducted research that required him to use math as an analytical tool.

M: How did you use math in the problem you worked on at the lab?
E: It was basically like 50/50 with doing math and actual science, because to take the sample we had to do all the measurements of the instrument that took the sample, then calculate the distance of the water sample, then calculate the volume of all the water samples, and then the sub-samples. Then once all of the organisms in the sample were identified, I guess, calculate those into all the sub-samples to see kind of the broad view of how many organisms are in the surrounding waters, and also taking filters of samples to see how many organisms create a dry weight on a filter to get another spectrum idea of how many organisms are in the water. It's all on the basis of using a small amount, and getting that information, and multiplying it to find out what the broader view is.

The research work at the lab gave Edward the opportunity to work independently, which he enjoyed.

With regards to school mathematics, I asked Edward about how he deals with all the rules:

M: How do you respond to all the rules?
E: I guess because I'm the kind of person who doesn't respond to authority well, and in a lesser sense, rules, I kind of like to do things on my own, and in my own way. I guess math is not that bad because the rules often times help you in being able to solve the problem. They keep you organized and keep you on track. … I guess the rules are more of a guideline than a kind of overbearing force that is trying to keep you strict or something. … I mean the greatest mathematicians figured out problems doing something a little abstract.

Data Analysis

The table below presents Edward's data in accordance with Wertsch's (1998) "*Ten basic claims*" about mediated action:

Wertsch's (1998) "*Ten basic claims*" (p. 25).	**Edward's Data**
Mediated action is characterized by an irreducible tension between agent and mediational means	An irreducible tension is evident in Edward's average test scores (i.e., Critical Reading **52nd** and Math **51st** National Percentiles), and his poor mathematics performance, at his former high school (Personal).
Mediational means are material	Cultural practices are material: Edward is a healthy, physically-fit young man who enjoys surfing, snowboarding, and doing yoga (Personal). Edward volunteers at a marine research laboratory (Personal).
Mediated action typically has multiple simultaneous goals	"Math is a very important part of my life considering I plan on becoming a marine scientist" (Essay). "I'm going to try and get away with doing as less math as possible" (Interview). These are examples of multiple simultaneous goals.
Mediated action is situated on one or more developmental paths	"When I was in Fourth grade I was considered especially smart and once a week went with a few other students to learn deeper studies. When I was in sixth grade I was a part of the advanced math class, but due to troubles at home, my grades dropped severely. This continued throughout the rest of my school career to the point where I am today" (Essay). These comments suggest several developmental paths.
Mediational means constrain as well as enable action	*Constrained* and *Enabled* by Edward's motivation and mood: "I did well when I tried. I mean, I came out with Bs and Cs when I decided I wanted to pay attention in class and do the work, but I also came out with some Fs and that's when I just wanted to sleep and do crossword puzzles and stuff. So it kind of differed on my mood for that

	quarter or semester" (Interview). Regarding calculating an exact tip: "Depends on if I feel like it" (Observation). *Enabled* by Edward's interest in becoming a marine scientist: "Math is a very important part of my life considering I plan on becoming a marine scientist" (Essay).
N*ew mediational means transform mediated action*	Edward gave a rich description of how he used math in his scientific research at the lab in which he volunteers (Personal, Interview): "It was basically like 50/50 with doing math and actual science …" (Interview). "It's all on the basis of using a small amount, and getting that information, and multiplying it to find out what the broader view is" (Interview). Knowing how to do math transformed Edward into a working marine scientist.
T*he relationship of agents toward mediational means can be characterized in terms of mastery*	Mastery is evident when Edward asserts: "All academic work including math has always come so easy to me that I don't even bother wasting my time trying it when I have bigger things to worry about" (Essay).
T*he relationship of agents toward mediational means can be characterized in terms of appropriation*	"There has only been a few times in my math career that I actually learned something from the teacher. All of my knowledge came from reading it out of the text book or getting it taught to me by someone like my sister" (Essay). This statement characterizes how Edward has individually appropriated school mathematics.
M*ediational means are often produced for reasons other than to facilitate mediated action*	Edward's emotions, with regard to his life at home, are produced for reasons other than to facilitate mediated action: "Because of my troubles at home, my mind was always focused on something else, and never what was being taught in the class room" (Essay).
M*ediational means are associated with power and authority*	Rules are associated with power and authority: "I guess because I'm the kind of person who doesn't respond to authority well, and in a lesser sense, rules, I kind of like to do things on my own, and in my own way. I guess math is not that bad because

	the rules often times help you in being able to solve the problem. They keep you organized and keep you on track. … I guess the rules are more of a guideline than a kind of overbearing force that is trying to keep you strict or something. … I mean the greatest mathematicians figured out problems doing something a little abstract" (Interview).

Preferring to do things by himself, or with the help of a close ally, Edward said that he did not work well with authority figures, illustrating how doing school mathematics independently mediated his identity. The work that he did in the marine research laboratory appeared to provide him with the right balance between instructional oversight and independence, and he recognized that knowing math would likely make him a better research scientist. Edward mediated a positive mathematical identity within these real-life experiences with school mathematics. In addition to school mathematics, his laboratory work was a practice in which he mediated his identities. When solving math-related problems, he liked the way that the rules of math kept him organized and on track. Nonetheless, Edward associated greatness in mathematics with problem-solving approaches that were abstract. In the data table, Edward reported that he was considered a bright child, and thus he was allowed to attend a special class, in which the students worked at a more advanced level than their classmates. Irrespective of this advantage, he linked his subsequent struggles in math to his personal problems at home. His story illustrated how his past experiences mediated his present identities in school mathematics. Edward admitted that his success with his coursework was heavily dependent upon his moods, which showed that he placed the utmost importance on his emotions when doing school mathematics.

James

Personal Data

- Age 16
- Grade 11 (High School Junior)
- Grew up in an executive community in the northeastern United States
- Father is a retired corporate leader and mother is a homemaker
- James is the youngest of three children. James has two older sisters.
- Preliminary Scholastic Aptitude Test (PSAT) taken in the fall of his Junior (Grade 11) year was **96th** National Percentile, superior performance overall. James's Critical Reading, Math, and Writing scores were each greater than 90th National Percentile.
- School Attendance & Math Progression:
  Grades kindergarten through eighth – private day schools, Arithmetic to Algebra;
  Grade 9 – elite private day school, Geometry (average grade);
  Grade 10 – elite private day school, Algebra II (average grade), therapeutic wilderness program for one month;
  Grade 11 – small boarding school, Pre Calculus.
- James is currently studying Pre Calculus.
- James is a talented athlete, who has competed in a variety of sports.

Student Essay

My Experience With Math

Thus far in my life, mathematics has shown itself in an abundance of practical applications and it has surely been one of the most loyal, faithful tools I have in my arsenal. The thing about math, for which the same can't be said about language or history, is that math is always definite and never flexible. There is no misinterpretation or change over time concerning derivatives and cosines as there could be for writing styles or historical events taken out of context. The whole practice of arithmetic is governed by a set of concrete laws, and there is always a *correct* answer. There is no absolutely *correct* way to write a research paper or to interpret poetry, and that is what makes math stand out to me.

I fell in love with math in elementary school, if I had to venture a guess I'd say it was in fourth grade. Every day, we would play a game called "Around the World," where one player would move from desk to desk and race against the student sitting at the desk to be

the first to answer the problem. Usually, one player would move a few desks, lose to another player, and then had to sit at their desk while the winner moved around the class. I quickly got tired of sitting around while someone stole the glory from me, and once lollipops were introduced as an incentive to win the most matches, I took the game very seriously. I studied math every night, memorizing all my times tables, developing an intimate relationship with division, and flying through fractions. By the second half of the year, I won a lollipop almost every day and I would often go all the way around the room without losing a match. I loved all the angry glares and scoffs when I won, and I've adored math ever since.

Now, I'm a junior in high school and I still try to bring the same energy into my pre-calculus course as I did during my glory days in "Around the World." I try as hard as I can to learn the basic principles before I jump into more complicated systems, because I know that I'll probably be using the material at some other time in my life. I want to go to business school after I graduate from college, and it seems like the stronger foundation I build today will only improve my chances at success in the future. Math seems to be one of the most useful man-made inventions to date, and I find myself using numbers many times in a day …so *that* is my experience with math.

Classroom Observations

James works extremely hard in the classroom, but he does not always continue that great effort on outside assignments.

Interview

James said he studied Geometry and Algebra II before arriving at the small boarding school.

M: How did it go for you?
J: Geometry went well. I was pretty good at Geometry except I could not get the proofs down so I ended up failing a couple of tests and ended the year with a C+.
M: So the proofs were difficult for you?
J: Yes, they were pretty easy for everyone else, but for some reason I could not understand them.

James described his difficulties with learning "theorems and axioms" in Algebra II.

J: It seemed like such a ridiculous thing to study.

James said he prefers math problems that involve a "real world application."

I asked James about his family's attitude toward math:

J: Well, my dad was really good at math, so I think he always liked math … it's not like he did anything that serious concerning math in college, but I guess that helped him when he went into business, and then my mom hates math, and neither of my sisters are really very strong in math either.

Data Analysis

The table below presents James's data in accordance with Wertsch's (1998) "*Ten basic claims*" about mediated action:

Wertsch's (1998) "*Ten basic claims*" (p. 25).	**James's Data**
M*ediated action is characterized by an irreducible tension between agent and mediational means*	An irreducible tension is evident in James's superior performance overall on the PSAT (**96th** National Percentile) and his average academic grades. Tension is also evident in how James works extremely hard in the classroom, but does not always continue that great effort on outside assignments (Observation).
M*ediational means are material*	Practices involving the body are material: "Every day, we would play a game called "Around the World," where one player would move from desk to desk and race against the student sitting at the desk to be the first to answer the problem. Usually, one player would move a few desks, lose to another player, and then had to sit at their desk while the winner moved around the class." (Essay) James is a talented athlete, who has competed in a variety of sports (Personal).
M*ediated action typically has multiple simultaneous goals*	"I want to go to business school after I graduate from college, and it seems like the stronger foundation I build today will only improve my chances at success in the future" (Essay). James wishes to avoid studying "theorems and axioms" (Interview). These are examples of multiple and

	simultaneous goals.
M*ediated action is situated on one or more developmental paths*	The physical and extroverted qualities associated with playing the "Around the World" game, versus the sedentary and introspective nature of doing geometric proofs, suggests several developmental paths (Essay, Interview). This is echoed in James's statement: "Now, I'm a junior in high school and I still try to bring the same energy into my pre-calculus course as I did during my glory days in "Around the World"" (Essay).
M*ediational means constrain as well as enable action*	*Constrained* by James's distaste for theorems and axioms: "It seemed like such a ridiculous thing to study" (Interview). *Constrained* by James's difficulty with geometric proofs: "they were pretty easy for everyone else, but for some reason I could not understand them" (Interview). *Enabled* by James's interest in using math to solve real life problems such as in business, which is a field that he wishes to study in college (Interview, Essay). *Enabled* by James's interest in winning the "Around the World" game. "I studied math every night, memorizing all my times tables, developing an intimate relationship with division, and flying through fractions" (Essay).
N*ew mediational means transform mediated action*	James's participation in the "Around the World" game transformed his approach to school math (Essay). James's initiation into the study of "theorems and axioms" was also transformative (Interview).
T*he relationship of agents toward mediational means can be characterized in terms of mastery*	Mastery is evident when James writes: "By the second half of the year, I won a lollipop almost every day and I would often go all the way around the room without losing a match" (Essay). Mastery or the lack of mastery is evident in James's comments about his family's attitude toward math: "Well, my dad was really good at math, so I think he always

	liked math … it's not like he did anything that serious concerning math in college, but I guess that helped him when he went into business, and then my mom hates math, and neither of my sisters are really very strong in math either" (Interview).
T*he relationship of agents toward mediational means can be characterized in terms of appropriation*	James articulates his relationship with math: "Math seems to be one of the most useful man-made inventions to date, and I find myself using numbers many times in a day …so *that* is my experience with math" (Essay).
M*ediational means are often produced for reasons other than to facilitate mediated action*	Competitive feelings are produced for reasons other than to facilitate mediated action: "I quickly got tired of sitting around while someone stole the glory from me" (Essay). "I loved all the angry glares and scoffs when I won, and I've adored math ever since" (Essay).
M*ediational means are associated with power and authority*	James associates math with power when he writes that "it has surely been one of the most loyal, faithful tools I have in my arsenal" (Essay). James associates math with authority: "The whole practice of arithmetic is governed by a set of concrete laws, and there is always a *correct* answer. There is no absolutely *correct* way to write a research paper or to interpret poetry, and that is what makes math stand out to me." (Essay)

Successfully doing school mathematics mediated James's identity, which was evident from his superior score on the mathematics portion of a national standardized test (PSAT). Physically oriented, and competitive, James approached school mathematics like a sport, as illustrated with his story of how he played the Around the World Game. In this endeavour, maintaining decorum and building personal relationships were less important to him than dominating the competition. He mediated his mathematical identity with his success in the

game, which placed him above the other students in his math class. Revelling in his competitive feelings, James tremendously enjoyed holding his higher position. His goal of pursuing a business career and studying college mathematics were compatible as he simultaneously mediated his multiple identities. Nevertheless, James professed an attachment to the simple and useful math, which, with repetitive practice, he could easily master and control. According to James, his much-loved arithmetic was based on *concrete* laws that led to *correct* answers. Less appealing to him were the geometric proofs that he had difficulty relating to real life situations. This pointed to several developmental paths. He stated that other people in his class understood the proofs better than he did. His lack of confidence with advanced work illuminated how James's past experiences mediated his present identity in school mathematics.

Arthur

Personal Data

- Age 17
- Grade 11 (High School Junior)
- Grew up in the western United States
- Mother owns a ranch (Absent father)
- Arthur is the youngest of two children
- Arthur opted not to take the Scholastic Aptitude Test (SAT I) and thus has no scores. The post-secondary school that Arthur wishes to attend does not require this test.
- School Attendance & Math Progression:
  Grades kindergarten through eighth – public schools, Arithmetic to Pre-Algebra;
  Grade 9 – private boarding school, followed by a therapeutic wilderness program, and a therapeutic boarding school, Algebra;

Grade 10 – traditional boarding school for one month, Algebra; small boarding school for the remainder of the school year, Algebra and Geometry.

Grade 11 – small boarding school, Business/Consumer Math.

- Arthur is currently studying Business/Consumer Math.
- Arthur is a healthy, outdoorsy, young man who is passionate about composing and producing electronic music.

Student Essay

Knowing my math helps me with simple things like averaging out the price of what I will pay when I buy things in bulk. I use math to produce music. Knowing proper banking math will help me manage my money correctly when I'm an adult. I always use my simple math to calculate how much money to use when I go home.

Classroom Observations

Comments made by Arthur during various lessons in Business/Consumer Math class:

A: If you call it a lecture, I won't like it.

A: I don't want to just sit in a classroom and listen to you talk or listen to a teacher talk at all. I like to be doing something.

A: No offense to you Melinda, but I'm never going to use any of this in my entire life.
In spite of his negative comments, Arthur appears to listen carefully to the information I present about the U.S. economy and economic policies.

Arthur articulated his plan to earn an advanced degree and start his own music production company:

"Get my Masters" and "make my own company" said Arthur, who wants to be "CEO boss" of "XYZ Productions." (Masters refers to an advanced degree; CEO is Chief Executive Officer; and XYZ Productions is the pseudonym of the company Arthur plans to found.)

Interview

Arthur expresses his opinion about learning school math:

A: I know my plus or minuses and that's all I'll ever really use, if I need it.

M: When you wrote your essay for me, you said you used math for music.
A: Oh yes, just 1, 2, 3, 4. I don't need to know a lot of complicated stuff.
M: Can you give me an example of how that might work?
A: How I use math in music?
M: Yes.
A: Well yes, sometimes in a lead-in I have to put 16 notes into 8 bars, but that's about as complicated as it gets. Just simple math, I don't need to know 'x' minus 'b' equals 'c'.

In the interview, Arthur emphasized that simple math was all he needed to know:

A: Just simple math, I mean that's all I really need to know, and I'm not going to waste my time with algebra.

M: Any topics from business math that you find interesting?
A: Yes.
M: Like what?
A: Money.

M: Are you interested in investing?
A: No.

Regarding money, Arthur made these comments:

A: I figure I handle my money better than any banker can.

A: I would just sit on it and use it for small things.

A: I wouldn't let anyone else handle my money.

A: Once I start making money, it's going to sit right next to me.

Arthur discusses his future career as a musician:

M: So what do you want to do for a career?
A: Just make music.
M: Any particular kind of music?
A: Hip Hop (pause) making instrumentals.

Data Analysis

The table below presents Arthur's data in accordance with Wertsch's (1998) "*Ten basic claims*" about mediated action:

Wertsch's (1998) "*Ten basic claims*" (p.	**Arthur 's Data**

25).	
M*ediated action is characterized by an irreducible tension between agent and mediational means*	In the past three years, Arthur has attended four different high schools and a therapeutic wilderness program (Personal). This suggests an irreducible tension.
M*ediational means are material*	Arthur's practices of composing and producing Hip Hop music and handling his own money are material (Interview).
M*ediated action typically has multiple simultaneous goals*	Arthur's career goal is to: "Just make music" (Interview). Arthur is quick to point out when things are not inherently useful: "No offense to you Melinda, but I'm never going to use any of this in my entire life" (Observation). "Get my Masters" and "make my own company" said Arthur, who wants to be "CEO boss" of "XYZ Productions." (Observation) This suggests multiple and simultaneous goals.
M*ediated action is situated on one or more developmental paths*	Arthur does not consider sitting in a classroom, listening to a teacher, as "doing something" (Observation). Opposition to classroom lectures and preference for physical activities suggest several developmental paths.
M*ediational means constrain as well as enable action*	*Constrained* by Arthur's refusal to study beyond simple math: "Just simple math, I mean that's all I really need to know, and I'm not going to waste my time with algebra" (Interview). *Constrained* by Arthur's dislike of teacher-directed lectures: "If you call it a lecture, I won't like it" (Observation). *Enabled* by Arthur's interest in music: "I use math to produce music" (Essay). *Enabled* by Arthur's interest in managing his money: "Knowing proper banking math will help me manage my money correctly when I'm an adult" (Essay).
N*ew mediational means transform mediated action*	In spite of his negative comments, Arthur appears to listen carefully to the information

	I present about the U.S. economy and economic policies (Observation). A transformation is evident in Arthur's willingness to listen to a presentation about macroeconomics.
T*he relationship of agents toward mediational means can be characterized in terms of mastery*	"I know my plus or minuses and that's all I'll ever really use, if I need it" (Interview). "I figure I handle my money better than any banker can" (Interview). These comments refer to mastery.
T*he relationship of agents toward mediational means can be characterized in terms of appropriation*	Arthur articulates how he has appropriated simple math: "Well yes, sometimes in a lead-in I have to put 16 notes into 8 bars, but that's about as complicated as it gets. Just simple math, I don't need to know 'x' minus 'b' equals 'c'." (Interview) "I always use my simple math to calculate how much money to use when I go home" (Essay).
M*ediational means are often produced for reasons other than to facilitate mediated action*	A need for control, and a lack of trust, is echoed in Arthur's comments about money: "I would just sit on it and use it for small things" (Interview). "I wouldn't let anyone else handle my money" (Interview). "Once I start making money, it's going to sit right next to me" (Interview). These feelings are produced for reasons other than to facilitate mediated action.
M*ediational means are associated with power and authority*	Managing money is associated with power and authority. Arthur acts with authority when he composes/produces electronic music.

Whilst he rejected doing traditional mathematical topics such as algebra, Arthur clearly stated that the only thing that he really needed to know was simple math, and that the only

thing he cared to do was make music. Structural discontinuities in his fragmented academic career provided evidence that, from a teacher's perspective, Arthur was a difficult student. Serving to mediate Arthur's negative mathematical identity was his view that doing school mathematics meant sitting in a classroom listening to a teacher talk. His opposition to classroom lectures, and his preference for physical activities, indicated several developmental paths, as well as how his past experiences mediated his present identity in school mathematics. Nevertheless, Arthur mediated a positive identity when he learned how to manage his money in Business/Consumer Math class, which permitted him to keep tight control over his personal finances. That Arthur transformed his mathematical identity with regard to money matters was suggested by his interest in class presentations about macroeconomics. Arthur appeared to enjoy developing his business idea of founding XYZ Productions in which he positioned himself as CEO. Arthur mediated his multiple identities in practices that facilitated his goal of becoming a music executive, opening the door to a long-term goal of an advanced degree. For Arthur, aspiring to a role associated with power and authority validated the idea of learning additional business applications of mathematics.

Jack

Personal Data

- Age 18
- Grade 12 (High School Senior)
- Grew up in the mid-western United States
- Father and Mother own and operate a business
- Jack is the oldest of four children
- Scholastic Aptitude Test (SAT I) taken in the fall of his Senior (Grade 12) year:
  Critical Reading (470) – **38th** National Percentile
  Math (380) – **11th** National Percentile

- School Attendance & Math Progression:
  Grades kindergarten through eighth – private day schools, Arithmetic to Pre-Algebra;
  Grade 9 through 11 – private day school, Algebra I, Geometry, Algebra II (D+), therapeutic wilderness program;
  Grade 12 – small boarding school.
  Jack is currently studying Business/Consumer Math.
- Jack is a healthy young man who enjoys football, snowboarding, and skateboarding.

Student Essay

Math w/ My life

Math in my life has been big. Mainly because my parents are in the car business so I've always been around numbers. Move on up through school and I learn what those numbers mean, and I learn how to use those numbers. Back to the car industry, once I learned how to do math, people at the dealership started to teach me how to use my skills in the car market. So since I was a little kid, I've been around math, learned about numbers, and even made money using math.

Classroom Observations

In Business/Consumer Math, Jack enjoys class discussions about the U.S. auto industry. He frequently offers examples from his family's car dealership.

Jack exercises creativity in his Business/Consumer Math assignments such as calculating the cost of designing and marketing a line of clothing for skateboarding.

Interview

The interview begins with Jack telling me that he needs to take two mathematics classes in order to fulfil the requirements of the college-level graphic design program, which he plans to attend next year.

In the past, Jack has used math to work out the proportions of various building projects such as a "grind-box" for skating. He liked the hands-on work involved in drawing up blueprints, as well as cutting and measuring the grind-box's parts.

Jack explains what he likes about graphic design work:

J: I love colour. I think the use of colour is what makes or breaks the image.

J: I like making stuff big (pause) really in your face. I like to do more detailed things. When it's smaller you can't hit as many details. You have to preserve space. When it's big you can go to town and have fun.

Jack relates his interest in design to school mathematics:

M: Did you like Geometry?
J: I did *good* in Geometry, it was the shapes and designs and stuff.
M: Can you look at something and know that it is a good design based on its proportions?
J: Yes, I do that all the time with buildings. Well, I like the way it's laid out, the floor, the ceiling height.
M: What about cars?
J: I do that with cars all the time (pause) looks like a box, too boxy; I like the lines, makes it look real sleek, fast when it's actually standing still. Design's everywhere. It's crazy. That's why I'm so interested in it.

Data Analysis

The table below presents Jack's data in accordance with Wertsch's (1998) "*Ten basic claims*" about mediated action:

Wertsch's (1998) "*Ten basic claims*" (p. 25).	**Jack's Data**
M*ediated action is characterized by an irreducible tension between agent and mediational means*	In Grade 11, Jack received a very low grade in Algebra II. (Personal) Jack exercises creativity in his Business/Consumer Math assignments such as calculating the cost of designing and marketing a line of clothing for skateboarding. (Observation).

	Tension is indicated by Jack's inconsistent school math performance.
M*ediational means are material*	Practices involving the body are material: Jack is a healthy young man who enjoys football, snowboarding, and skateboarding. (Personal) Jack liked the hands-on work involved in cutting and measuring the grind-box's parts. (Interview) Jack likes to do graphic design work. (Interview)
M*ediated action typically has multiple simultaneous goals*	Jack wants to remain associated with his family's business: In Business/Consumer Math, Jack enjoys class discussions about the U.S. auto industry. He frequently offers examples from his family's car dealership. (Observation) Jack plans to enrol in a college graphic design program. (Interview) This suggests multiple and simultaneous goals.
M*ediated action is situated on one or more developmental paths*	In his essay, Jack juxtaposes his experience as a learner of mathematics with his childhood development: "So since I was a little kid, I've been around math, learned about numbers, and even made money using math" (Essay).
M*ediational means constrain as well as enable action*	*Constrained* by Jack's inconsistent academic history and below average standardized test scores. (Personal) *Enabled* by Jack's motivation to fulfil the requirement of studying two mathematics courses in his college graphic design program. (Interview)
N*ew mediational means transform mediated action*	Jack describes a transformative experience: "Back to the car industry, once I learned how to do math, people at the dealership started to teach me how to use my skills in the car market" (Essay).
T*he relationship of agents toward mediational means can be characterized in*	Jack refers to mastery when he said, "I did good in Geometry, it was the shapes and

terms of mastery	designs and stuff" (Interview).
T*he relationship of agents toward mediational means can be characterized in terms of appropriation*	In the past, Jack has used math to work out the proportions of various building projects such as a "grind box" for skating (Interview). "I like making stuff big (pause) really in your face. I like to do more detailed things. When it's smaller you can't hit as many details. You have to preserve space. When it's big you can go to town and have fun" (Interview).
M*ediational means are often produced for reasons other than to facilitate mediated action*	Jack's aestheticism with regard to colour and proportion is produced for reasons other than to facilitate mediated action: "I love colour. I think the use of colour is what makes or breaks the image" (Essay). "Yes, I do that all the time with buildings. Well, I like the way it's laid out, the floor, the ceiling height" (Interview). "I do that with cars all the time (pause) looks like a box, too boxy; I like the lines, makes it look real sleek, fast when it's actually standing still" (Interview).
M*ediational means are associated with power and authority*	Jack associates math with his parent's power and authority: "Math in my life has been big. Mainly because my parents are in the car business so I've always been around numbers" (Essay). Jack views design as a source of power: "Design's everywhere. It's crazy. That's why I'm so interested in it" (Interview).

Suggesting how doing school mathematics mediated his mathematical identity, Jack's inconsistent performance paralleled his below-average grades and standardized test scores (SAT). Nevertheless, he mediated a positive identity in Business/Consumer Math class, even though his primary focus was design. Jack demonstrated that he was motivated to

learn the math that he needed to know in order to succeed at his future career as a graphic designer. As he mediated his identities in other practices, Jack was enthusiastic about a college graphic design program in which he planned to take several applied mathematics courses. Recalling his previous math-related work, he reported that he enjoyed the visual components of geometry, the cutting and measuring involved in building a half-pipe, and the math that he used to make money at his parent's car dealership. Jack's past experiences with activities, which offered tangible outcomes and social experiences, mediated his present identity in school mathematics.

Overview Comment

Before moving on to a more detailed discussion, I reflect upon the case studies in conjunction with my research questions. With a view towards my first question, the case studies suggested that irreducible tensions associated with doing school mathematics mediated the boys' identities. Discontinuous school attendance and conflicts between objective and subjective identities were examples. The boys' experiences with school mathematics were transformative as they formed new mathematical identities with respect to fresh practices. It was apparent from the case studies that the boys appropriated school mathematics in unique ways.

Shedding light on my second question, how the boys mediated their identities in school mathematics appeared to constrain as well as to enable their performances. From the boys' perspective, mathematical identities secured a variety of positions. The case studies provided evidence that the boys were concerned about their mastery of school mathematics, and that their emotions and their mathematical identities were entangled.

My third research question inquired as to how the boys mediated their identities in school mathematics in conjunction with their identities shaped by other social practices. The case studies indicated that the boys had multiple and simultaneous goals. Associated with power and authority, mathematical identities were often empowered by exchange resources. Material means such as physical activities communicated identities that were sometimes compatible with mathematical identities.

Concerning my fourth question, the boys appeared to mediate their present mathematical identities with their past experiences in school mathematics. The case studies suggested that doing school mathematics was situated on one or more developmental paths. Structured around my research questions, I consider many examples from the analytical tables in the next chapter.

CHAPTER 5

DISCUSSION

Introduction

My data analysis chapter synthesized Wertsch's (1998) "*Ten basic claims*" about mediated action with the structural and emergent properties of identity in a table format. In accordance with this working theoretical framework, I discuss how the findings 'answer' my research questions. Each of the four research questions discussed below includes the appropriate *claims* and data, which I extracted from the boys' tables. Data tables for each boy appeared in the previous chapter. Focusing on the boys' identities, I show how this data, as matched to the *claims*, relates to the existing research contained in my literature review. I conclude this chapter with the larger ideas about identity, struggling teenage boys, and school mathematics that emerged from my analysis.

How Doing School Mathematics Mediates the Identities of 'Struggling' Teenage Boys

Structural Tensions and Institutionally Imposed Identities

My first research question asked, "How does doing school mathematics mediate the identities of 'struggling' teenage boys?" That all of the boys had multiple discontinuities in their school attendance was indicated by the data that I matched to Wertsch's (1998) claim, "***mediated action is characterized by an irreducible tension between agent and mediational means***" (p. 25). These findings suggested that doing school mathematics amid irregular school attendance represented a structural tension that occurred at the same time as the boys constructed their mathematical identities. Multiple transitions required the boys to adjust to new academic circumstances in combination with the stresses and strains of doing school mathematics. Broken school attendance, documented on their transcripts,

constituted a “stigma” or a deviation from the norm, since chequered academic histories need always be explained to prospective colleges and employers (Goffman, 1986). With respect to school mathematics, the term ‘struggling’ was used to designate an institutionally imposed identity that encompassed below average standardized test scores, poor course grades, and alternative classes such as my Business/Consumer Math.

An overview of the boys’ academic histories appears in the table below, reports the number of high schools/programs that they attended, and also provides their progression of math courses:

	Tyler	**Adam**	**Raymond**	**Edward**	**James**	**Arthur**	**Jack**
Grade	12	10	10	12	11	11	12
Number of High Schools/Programs	3	4	3	2	3	5	3
High School Math Progression	Pre-Alg., Alg. & Geo., None, Bus./ Cons. Math	Pre-Alg., Alg., Alg. & Geo.	Geo., Alg. II & Geo.	Alg. I, Geo., Alg. II, Adv. Alg.	Geo., Alg. II, Pre Cal.	Alg., Alg. & Geo., Bus./ Cons. Math	Alg. I, Geo., Alg. II, Bus./ Cons. Math

Edward, who went to one public school before arriving at the small boarding school that was the setting for my study, had attended the least number of high schools and programs. Tyler, Raymond, James, and Jack attended two different high schools as well as a therapeutic school or program. Adam, who attended three high schools and a therapeutic wilderness program, and Arthur who attended three different high schools, a therapeutic boarding school, and a wilderness program had the greatest number of transitions.

The boys’ experiences sometimes differed from the institutional norm of continuity, where each step in the mathematics curriculum builds upon the preceding one. For example, in the

United States, a typical college preparatory progression for high school students is first year algebra, geometry, second year algebra, followed by topics such as trigonometry, probability/statistics, and pre-calculus. Only James appeared to be efficiently on this track. At the other end of the spectrum were Tyler, Arthur, and Jack, who had abandoned traditional college-preparatory math, and were studying Business/Consumer Math. All of the boys had a pattern of average or below average grades in their mathematics classes before arriving at the small boarding school where my study took place. Tyler and Jack also had below average standardized test scores in math.

New Mathematical Identities

The findings that I matched to Wertsch's (1998) claim, "***new mediational means transform mediated action***," provided examples of how the boys' experiences with school math encouraged them to remodel their mathematical identities **(**p. 25). Constructing new mathematical identities appeared to have empowered, or hindered, the boys within social institutions (McCall & Simmons, 1978). For example, when Adam thoughtfully recalled that learning addition and subtraction opened up new opportunities for him in the world, he articulated a positive mathematical identity.

Similarly, Raymond was empowered by being designated as "gifted" in the second grade, since it allowed him to study math at an advanced level. Raymond told his story as follows:

> In second grade my mom realized that I was really smart so she got me tested for a gifted program, which is an advanced program. I got like a 97 in math and 92 in reading and so I moved to gifted in third grade and just stayed with advanced classes until 7th grade (Interview).

Raymond's new identity of being "gifted" was assigned to him by a social institution. Judging by his own emphasis on the number, it was evident that Raymond's test score of

"97" in math was an important characteristic of his mathematical identity. This finding aligns with William, Bartholomew, and Reay's (2004) study in which students' mathematical identities became their designated levels on standardized assessments.

A few of the boys constructed new mathematical identities, based on activities outside the classroom. As a volunteer at a marine research laboratory, Edward used math in his scientific work. Edward articulated the mathematical essence behind biological sampling when he said, "It's all on the basis of using a small amount, and getting that information, and multiplying it to find out what the broader view is" (Interview). Edward's hands-on work, in which he gained a conceptual understanding, mediated his mathematical identity. Jack also became empowered by math in the workplace, as he wrote that after he learned math, "people at the dealership started to teach me how to use my skills in the car market" (Essay). His story related to his study of Business/Consumer Math, which addressed his new identity as an emerging adult.

On the other hand, Tyler resisted the exercise of simulating adulthood by putting his head down on the desk, a gesture that conveyed that he was uninterested in estimating and monitoring his personal expenses such as rent. Both empowered and hindered by new mathematical identities, James was enthusiastic about playing the "Around the World" game, yet he was reticent about learning "theorems and axioms" (Interview). Another interesting example was how Arthur, who was one of the most difficult students to engage, paid attention to a presentation about macroeconomics in Business/Consumer Math class. These examples illustrate the dynamic nature of mathematical identity.

Individual Appropriations

That individual ways of doing mathematics mediated the boys' mathematical identities was suggested by the data I matched to Wertsch's (1998) claim, "***the relationship of agents toward mediational means can be characterized in terms of appropriation***" (p. 25). Appropriation refers to how boys negotiate their mathematical identities in the dialectic of society (Berger & Luckmann, 1966). Several of the boys called attention to the usefulness of math in solving everyday problems in real life settings. James referred to math as "one of the most useful man-made inventions to date," and he said that he used numbers frequently during the day (Essay). Arthur also touted the practical aspects of math when he said, "I always use my simple math to calculate how much money to use when I go home" (Essay). He also provided a basic example of how he used simple math when he composed music. Articulating a preference for "making stuff big," Jack used math when he designed and built a "grind box" for skating (Interview). Practical usage of school mathematics mediated these boys' mathematical identities.

Lave (2003) argued that a mathematical problem or dilemma has a resolution shape that may involve a physical activity. In his interview, Raymond recalled a particular type of shopping dilemma:

> When you buy stuff in stores they can rip you off. They can give you the wrong amount of money and if you know math, you realize – *wait*, this is not the right amount of change, which for some reason I always think about when I buy something. I never just take the money and walk out. I always look at it, count it, and realize how much money I paid for it. (Interview)

Upon receiving money back from a shopkeeper, Raymond described how he looked at it, counted it, and realized the sales price he paid, in order to decide if he received the correct change. As with Lave's (2003) grocery shoppers, who interacted with the displays in order

to find the best buy, solving a math problem was a process of negotiation. Raymond's mathematical identity is mediated by his physical appropriation of his correct change problem.

Learning school mathematics in the classroom typically requires the student to interact with a teacher, who presents materials such as problems in textbooks. In geometry class, Adam said that it was "fun" to solve problems involving angles (Interview). Consulting a textbook is a particular way of doing school mathematics that was mentioned by some of the boys. Edward voiced his preference for learning out of a textbook when he recalled:

> There has only been a few times in my math career that I actually learned something from the teacher. All of my knowledge came from reading it out of the text book or getting it taught to me by someone like my sister" (Essay).

Edward's appropriation reflects his independent-mindedness, and need for a supportive personal tutor. For the purpose of learning math, a textbook and an individual confidant afforded him greater flexibility than a lesson delivered by a teacher. Tyler committed to minimal participation in learning math, though he recognized the importance of textbooks. Referring to mathematics as 'magic', Tyler writes, "I feel that as long as the magic is written down in a book somewhere I can look it up if ever I need it" (Essay). Whilst Adam was compliant with his teacher's lesson plan, Tyler and Edward adopted an autonomous stance. These approaches mediated their mathematical identities.

How 'Struggling' Teenage Boys Mediate Their Identities in School Mathematics

Mathematical Identities and Positions

My second research question asked, "How do 'struggling' teenage boys mediate their identities in school mathematics?" How the boys mediated their identities in school

mathematics was evident in the data that I matched to Wertsch's (1998) claim, "***mediational means constrain as well as enable action***." Their mathematical identities reflected various characteristics of performing school mathematics such as rigour, competition, acceleration, precocity, and carrying out abstract practices. The social role of 'learner of mathematics' also marked certain positions for them, which may have restricted, in addition to permitted, their advancement within social institutions (McCall & Simmons, 1978). Examples that I found of both of these scenarios are discussed below.

The boys' communications suggested that they constrained their performances in school mathematics with a variety of identity positions, ranging from outright defeat to refusal to participate. On the defeatist end of the spectrum, Tyler wrote, "My inability to understand algebra creates a huge aversion to it" (Essay). His assertion was likely his reaction to algebra's rigour, which he thought was beyond his abilities. In his essay, Adam asserted a similar position when he wrote, "I've never really been good at it" (Interview). With regard to his difficulty with carrying out the abstract practices of geometric proofs, James said, "they were pretty easy for everyone else, but for some reason I could not understand them" (Interview). These boys' defeatist positions in school mathematics were communicated with a tone of disinterest. Adam wrote, "I have taken math courses throughout my whole life. I find them to be very time consuming and boring" (Essay). In Business/Consumer Math, Tyler said, "Doing something so simple is wasting my life" (Observation). An otherwise competent math student, James articulated his distaste for theorems and axioms: "It seemed like such a ridiculous thing to study" (Interview). Admitting defeat and discounting the implications of the problem appear to have gone hand in hand.

On the opposite end of the spectrum were the boys who refused to do certain mathematical tasks. Raymond insisted that he did not need to study math outside of class, which included his homework. He said, "I don't really study it; I feel that it just comes to my head easily and I don't study that much at home" (Raymond, Interview). Based on this comment, it is evident that Raymond's sense of being "gifted" defines his mathematical identity. Precocity was a characteristic that Raymond associated with achievement in school mathematics. Regarding calculating an exact tip at a restaurant, Edward summarized his position towards doing school mathematics when he said, "Depends on if I feel like it" (Observation). Important to note, was Edward's level positioning with respect to his father, in this scenario. As a young adult, Edward asserted his independence by calculating the tip in his own way, despite his father's objections. Sharing an opposition to authority, Arthur's mathematical identity held a position for him that was superior to his teacher. This served to constrain his progress, because it made listening to classroom lectures unbearable for him. Arthur told me, his math teacher, "If you call it a lecture, I won't like it" (Observation). Citing its lack of applicability, Arthur disputed any mathematical task that challenged him to move beyond arithmetic, "Just simple math, I mean that's all I really need to know, and I'm not going to waste my time with algebra" (Interview).

The data revealed that the boys' mathematical identities related to social positions such as a 'post secondary education' and a 'future career.' These desired positions appeared to have provided them with goals, which enabled their performances in school mathematics. For example, Adam wrote, "I have always wanted to be a mechanic or engineer of some sort, so math would be extremely important" (Essay). His mathematical identity aligned with the technical characteristics of mathematics. With a view towards someday operating a

business, Raymond said, “You need to know a lot of math to have a business” (Interview). Also based on his career aspirations, James wanted to solve real life math problems related to business (Interview, Essay). With regards to his future career, Edward articulated a positive mathematical identity when he wrote, “Math is a very important part of my life considering I plan on becoming a marine scientist” (Essay). Looking towards college, Jack was motivated to fulfil his requirement of studying two mathematics courses in his college graphic design program (Interview). Though not specific to any particular career, Arthur’s mathematical identity held a position for him in the adult world when he wrote, “Knowing proper banking math will help me manage my money correctly when I’m an adult” (Essay).

Raymond linked his positive mathematical identity to his belief in the great importance of school mathematics. He wrote, “I have always enjoyed doing math. I feel that math is by far the most important subject that you can learn” (Raymond, Essay). Viewing the world through a wide-angled lens, Tyler communicated his sense of wonder when he admitted that he was “fascinated by the beauty and symmetry of the natural world” (Essay). His mathematical identity reflected his need for order and control, which were qualities associated with mathematics (Walkerdine, 1990). Tyler conveyed his logical approach to building things with legos. In his essay, he wrote, “My childish mind could not allow me to create anything that was not perfectly symmetrical and even coloured” (Tyler, Essay). In a game that emphasized speed and accuracy, James’s winning position was gained through his successful rivalry with other students, which reflected the competitive characteristic of school mathematics mentioned by Thurston (1990). James’s math performance was enabled by his interest in winning the “Around the World” game, as he wrote, “I studied math every

night, memorizing all my times tables, developing an intimate relationship with division, and flying through fractions" (Essay).

Mathematical Identities and Mastery

The data that I matched to Wertsch's (1998) claim, "***the relationship of agents toward mediational means can be characterized in terms of mastery***" showed how the boys mediated their mathematical identities in mastery over school mathematics (p. 25). Some of the boys linked their mathematical identities to the mastery that they believed came from hard work and practice. With regard to school mathematics, Adam said, "I guess it will be something that I'd like to learn more how to do, and do it more frequently, so that I can become better at it" (Interview). He acknowledged that it would require time to improve his skills, "I'd like to get better at it, but things take time, especially math" (Adam, Interview). Likewise, James reported that he gained competency by practicing arithmetic problems on his own, so that by the second half of the year, he "won a lollipop almost every day" and would "often go all the way around the room without losing a match" (Essay). Tyler was also concerned about the connection between work and mastery when he said, "Addition and subtraction were concepts that I could dissect, understand and work with" (Essay). In an interview, Tyler expressed that algebra was difficult for him to learn, "I had it all figured out until algebra, which is basically like learning another language" (Interview).

Most of the boys associated mastery over math with fondness for math. In other words, success with mathematical tasks implied positive mathematical identities (Ernest, 2004). Raymond's comments articulated this position, "I'm good at math so I kind of like it" (Interview). "I like Algebra, I'm good at algebra," and "numbers come easy to me"

(Raymond, Interview). According to Raymond, his brother was "really good at math" as well (Interview). Together, Raymond and his brother were a winning team in math. James assumed that people who were good at math also liked math, "Well, my dad was really good at math, so I think he always liked math" (Interview). Tyler thought "Einstein's good at math" (Interview). To Tyler, Einstein's positive mathematical identity represented mastery over the laws of the universe.

Some of the boys were very outspoken about their superior abilities. Edward boasted about his mastery over his studies in general, "All academic work including math has always come so easy to me that I don't even bother wasting my time trying it when I have bigger things to worry about" (Essay). According to Edward, his high level of competence saved him study time, and thus freed him up to deal with his personal problems at home. Arthur's confidence was reflected in his statement, "I know my plus or minuses and that's all I'll ever really use, if I need it" (Interview). His mastery over Business/Consumer Math allowed him to assert, "I figure I handle my money better than any banker can" (Interview). Jack also linked his mathematical identity to mastery when he said, "I did good in Geometry, it was the shapes and designs and stuff" (Interview). Mastering these topics enhanced his prospects of becoming a graphic designer.

Mathematical Identities and Emotions

How the boys mediated their mathematical identities in conjunction with their emotions was evident from the data that I matched to Wertsch's (1998) claim, "***mediational means are often produced for reasons other than to facilitate mediated action***" (p. 25). Mathematical identities are associated with learners' feelings about their performance in

school mathematics (Ernest, 2004). That identities may arise from emotions, such as shame, was discussed by Lynd (1965). For example, Tyler's embarrassment at not being good at math was triggered by Mr. Mellon's sense of humour, which Tyler believed was targeted at people who were not good at math (Interview). Struggles with math pertained to other family members too. Tyler repeated the story of how the near failing, D-minus grade that his father received on a math exam had a "minus sign that extended all the way across the paper," which emphasized how close his father came to not passing the test (Interview).

Two other boys articulated negative emotions with regard to school mathematics. Adam expressed his feelings of failure towards school mathematics when he said, "I've never really been good at it" (Interview). At the time he made the statement, Adam had improved his performance. Nevertheless, his pessimistic feelings lingered. Edward reported that his emotions about his life at home interfered with his school work, "Because of my troubles at home, my mind always focused on something else, and never what was being taught in the class room" (Essay). He mediated his mathematical identity with the emotional distraction of his home life in mind, as it justified his inconsistent effort in school mathematics.

Not everyone articulated negative emotions. For example, Raymond's feelings of self-confidence were very positive. With regard to school mathematics, Raymond said, "I just felt like I knew how to do it" (Interview). James's competitive feelings motivated him to excel in arithmetic. About playing the "Around the World Game," James wrote, "I quickly got tired of sitting around while someone stole the glory from me" (Essay). "I loved all the angry glares and scoffs when I won, and I've adored math ever since" (James, Essay). His positive mathematical identity was mediated by his competitive emotions.

Emotions were also associated with a boy's interest in topics related to math. As an individual interested in design, Jack's emotions arose from his aesthetic taste, like his love of colour (Interview). During his interview, he discussed how mathematical proportions applied to car design. He said of a car's proportions, "I like the lines, makes it look real sleek, fast when it's actually standing still" (Interview). Jack mediated his mathematical identity in his positive feelings about mathematical proportion. A need for control, as well as a lack of trust, is echoed in Arthur's comments about money. He assumed that he would "just sit on it and use it for small things," and he "wouldn't let anyone else handle" his "money" (Arthur, Interview). Arthur said, "Once I start making money, it's going to sit right next to me" (Interview). Though Arthur had a generally negative stance, his assertions about money revealed his positive interest in financial matters, which proved to be a "door-opener" in the mathematics classroom.

How 'Struggling' Teenage Boys Mediate Their Identities in School Mathematics and Their Identities Shaped By Other Social Practices

Numerous and Concurrent Strategies

My third research question asked, "How do 'struggling' teenage boys mediate their identities in school mathematics and their identities shaped by other social practices?" How the boys mediated their identities in school mathematics and their identities shaped by other social practices was made evident by the data that I matched to Wertsch's (1998) claim "***mediated action typically has multiple simultaneous goals***" (p. 25). Mediated action is composed of numerous and concurrent strategies, which the individuals employ in order to manage a cluster of social identities (Lofland, 1976). The "degree of cohesiveness" or

interrelatedness describe how clusters of social identities are associated with activities that require similar skills (McCall & Simmons, 1978, p. 74).

The data indicated that the boys' mathematical identities had a high degree of cohesiveness with their future career identities. Raymond clearly articulated in his interview and essay that he wished to pursue a career in business: "I would like to major in business when I get older" (Raymond, Essay). In his interview, Raymond also said that it was important for him to learn math, "Yes, it would be good for me in the long run, I think, to know math" (Interview). There was also an indication that Raymond's identity as a younger brother was embedded in his business and math cluster, when he said, "Business, I'd like to work in something to do with business with my brother" (Interview). For Raymond, the concurrent roles of math student, future businessman, and younger brother were apparently compatible.

Several other boys mediated their mathematical identities in their plans for future careers or education. Edward wrote that, "Math is a very important part of my life considering I plan on becoming a marine scientist" (Essay). With a view towards his future education, James touted the benefits of building a solid foundation of math skills when he wrote, "I want to go to business school after I graduate from college, and it seems like the stronger foundation I build today will only improve my chances at success in the future" (Essay). On the other hand, staging problems appeared to be a factor for both Edward and James. This was apparent when Edward said, "I'm going to try and get away with doing as less math as possible" (Interview). Similarly contradictory to his own plan, James wished to avoid studying "theorems and axioms" (Interview). These statements implied that the boys

employed numerous and concurrent strategies, which likely corresponded to other role identities that were incompatible with their roles as mathematics students.

Adam articulated his contradictory position when he wrote, "I have never really been a big fan of math, or doing math for that matter, but I know that it would be worth it in the long run" (Essay). Though he wished to avoid time-consuming and boring tasks, Adam saw himself using math after high school, and thus he wanted to improve his competency (Interview). His mathematical identity had a high salience, or relative importance, due to the intrinsic, and extrinsic, gratification of a successful future career (McCall &Simmons, 1978, p. 82). Staging a positive performance in the classroom, Adam was attentive as he steadily attempted practice problems and participated in class discussions (Observation).

The data suggested that the boys arranged each of their social identities in a "prominence hierarchy," according to each identity's salience (McCall & Simmons, 1978). Arthur's musician identity, which was associated with his career goal to "just make music," appeared to be at the top of his prominence hierarchy (Interview). In the mathematics classroom, Arthur was quick to point out when topics were not inherently useful with respect to realizing his goal, "No offense to you Melinda, but I'm never going to use any of this in my entire life" (Observation). Arthur's identity as a musician gave him both intrinsic and extrinsic gratification, as he asserted his goals to "Get my Masters," "make my own company" and be "CEO boss" of "XYZ Productions" (Observation). Arthur placed the greatest importance on his social identities that cohered to his future music-executive role.

Wishing to retain his identity associated with his family's car dealership, Jack enjoyed Business/Consumer Math class discussions about the United States automobile industry, as they gave him the opportunity to offer examples from his own experience (Observation). However, Jack's mathematical identity, as it related to his plans to enrol in a college graphic design program, and to pursue a future career as a graphic designer, had greater importance for him (Interview). The salience of role identities depends upon opportunities to profitably enact them in the current situation (McCall & Simmons, 1978, p. 82).

Tyler's complex case presented numerous and concurrent strategies with regard to his mathematical and other social identities. He wrote that, "As a child I did not have very refined concepts of morals, which made the consequences of my parents seem outlandish" (Tyler, Essay). Tyler also writes, "Things that did not make sense to me frustrated me to no end" (Essay). Because Tyler wished to avoid frustration, he thought it would be impossible for him to work like Stephen Hawking, solving problems in astronomy using mathematics (Essay). Rather, he desired to focus on things that had personal meaning to him. Though he said he did not understand the algebra, his goal was to keep algebraic equations in his "arsenal of magic" (Essay). Tyler said, "I feel that as long as the magic is written down in a book somewhere I can look it up if I ever need it" (Essay). Knowing where to find algebraic tools allowed him to avoid memorizing them. This creative strategy made it possible for Tyler to stage his mathematical identity above his level of competency in secondary algebra.

Mathematical Identities and Exchange Resources

The data that I matched to Wertsch's (1998) claim that "***mediational means are associated with power and authority***" illuminated how the boys' mathematical and other identities were supported by exchange resources. Money, status, authority, knowledge, and skills are examples of exchange resources (McCall & Simmons, 1978, p. 155). Since the boys associated school mathematics with all of these things, the empowering effects of exchange resources were reflected in their mathematical identities.

James acknowledged the power of his math skill when he called it "one of the most loyal, faithful tools" that he had in his "arsenal" (Essay). Doing arithmetic, according to James, produced exact outcomes:

> The whole practice of arithmetic is governed by a set of concrete laws, and there is always a *correct* answer. There is no absolutely *correct* way to write a research paper or to interpret poetry, and that is what makes math stand out to me. (James, Essay).

James's view aligned with those of Boaler and Greeno's (2000) learners observed in didactic classes, who liked mathematics "because there were only right and wrong answers" (p. 185). James appeared to enjoy the metonymic form of arithmetic, in which simple equations were devoid of metaphoric content (Walkerdine, 1990).

Despite his difficulty with authority, Edward valued the rules associated with school mathematics, which empowered him to keep order when he solved a problem:

> I guess because I'm the kind of person who doesn't respond to authority well, and in a lesser sense, rules, I kind of like to do things on my own, and in my own way. I guess math is not that bad because the rules often times help you in being able to solve the problem. They keep you organized and keep you on track. … I guess the rules are more of a guideline than a kind of overbearing force that is trying to keep you strict or something. … I mean the greatest mathematicians figured out problems doing something a little abstract. (Edward, Interview)

Just as Barnes's (2000) Technophiles did math on their own, Edward preferred to work independently. Rules aside, Edward suggested that great mathematicians sometimes did abstract work in order to solve difficult problems.

Tyler associated mathematics with magic, God, and the universe, all sources of power and authority. Tyler wrote that, "Math has always been like magic to me" (Essay). God, according to Tyler, was the "ultimate strain of logic or the perfect mathematical truth" (Essay). Tyler asserted that if we had perfect mathematical truth, "I'm sure that the universe would be as predictable to us as the answer to 1 + 1" (Essay). If only in fantasy, Walkerdine (1990) argued that the harnessed resource of mathematics provided the means to predict and to control incidents. Tyler's mathematical identity was compatible with math's placement in this powerful position.

Raymond wrote, "I think that math controls the world, especially with money" (Essay). By mentioning the word 'world,' he associated mathematics with all exchange resources, including money. In the mathematics classroom, Raymond often stirred up competition with the other boys (Observation). His behaviour was similar to Barnes's (2000) Mates, who liked to maintain a dominate position within a group. Like Raymond, these boys engaged in attention-seeking antics during mathematics lessons.

Jack discussed school mathematics as it applied to effective design. He implied that design was an exchange resource when he said, "Design's everywhere. It's crazy. That's why I'm so interested in it" (Interview). Jack also expressed that numbers were an important aspect of his parent's car dealership business, when he wrote, "Math in my life has been big.

Mainly because my parents are in the car business so I've always been around numbers" (Essay). Jack's mathematical identity was mediated in activities that he enjoyed, including making designs and selling cars.

Sometimes incorporating simple math, Arthur assumed an authoritarian position when he composed and produced electronic music. Knowing how to do this was an exchange resource that supported Arthur's identity as a musician. This identity, along with his money-manager identity, was compatible with his mathematical identity, so long as the math he did was straightforward. Adam also associated enhanced career opportunities with power and authority. Indicating that math skills were an exchange resource for him, he wrote, "Math is something that I would like to expand on because it would allow me to have more possibilities later on in life" (Essay).

Mathematical Identities and Physical Activities

That the boys had social identities associated with physical activities was indicated by the data that I matched to Wertsch's (1998) claim, "***mediational means are material*** (p. 25). In my study, 'material' corresponded to elements of a cultural practice such as "body, style, demeanour," and "the use of commodities" within a particular setting (Willis, 2000, p. 12). These material entities were associated with various social identities. The sports activities that they performed in school pertained to the construction of their male identities, as sports programs served as masculinity-making enterprises (Connell, 1987, 2000, 2005). For example, Tyler enjoyed kickboxing, whilst Edward liked surfing, snowboarding, and doing yoga (Personal). Jack pursued football, snowboarding, and skateboarding (Personal). Adam

was interested in anaerobic weight training. Both versatile athletes, Raymond and James competed in a variety of sports (Personal).

Competitive practices that emphasized speed and skill were associated with athletic programs, as well as school mathematics exercises (Thurston, 1990). James described a classroom mathematics game that had many of the elements of a sports competition:

> Every day, we would play a game called "Around the World," where one player would move from desk to desk and race against the student sitting at the desk to be the first to answer the problem. Usually, one player would move a few desks, lose to another player, and then had to sit at their desk while the winner moved around the class (James, Essay).

Judging from his enthusiasm towards the game, James's mathematical identity was compatible with his identity as an athlete.

Using one's own hands to perform a math-related task was another theme that emerged from the data. Linked to his interest in skateboarding, Jack liked the hands-on work involved in cutting and measuring a grind-box's parts, which was a positive experience for him (Interview). Jack also said that he enjoyed doing graphic design work (Interview). Within these practices, Jack's identities associated with skateboarding, constructing skating accessories, and creating graphic designs, appeared to be compatible with his mathematical identity. Adam articulated that he wanted to use his hands, building things, in some technically-oriented future vocation (Interview). Edward engaged in hands-on activities that required him to use math when he volunteered at a marine research laboratory (Personal). Mathematical activities such as these allowed for a rich expression of the boys' mathematical identities.

Other references to school mathematics and physical activities appeared in the data. Raymond wrote about using math to account for money, "Even when you go to a store to buy something, you use math to count the money you get back" (Essay). Raymond was sometimes disruptive during math lessons. According to my observations, his actions may be characterized as humorous and/or attention-seeking, which mirrored the classroom behaviour of a group of boys that Barnes (2000) called the Mates. Using a physical gesture that conveyed his disinterest, Tyler placed his head down on the table in order not to participate in a practical discussion about how one kept track of personal expenses or managed a checkbook/checking account (Observation). He described his former math teacher as "a computer geek type of guy," which disassociated Tyler from members of a particular subculture he assumed were skilful at math (Interview). For Arthur, the practices of composing and producing Hip Hop music and learning to handle his own money in Business/Consumer Math class were material.

How the Boys' Past Experiences Mediate Their Present Identities in School Mathematics

My fourth research question asked, "How do the boys' past experiences mediate their present identities in school mathematics?" The findings that I matched to Wertsch's (1998) claim, "***mediated action is situated on one or more developmental paths***" provided examples of how the boys' past experiences mediated their present mathematical identities (p. 25). Negotiated within the dialectic of society, their identities included both internal and external factors (Berger & Luckmann, 1966). The signifying practice of the boys' construction of their mathematical identities required inwardly- and outwardly-directed communication, and served psychological as well as social purposes (Shaw, 1994).

For example, in his essay, Tyler juxtaposed his role as a learner of mathematics with his social development from preschool to the present time (Essay). Jack also paralleled his experience as a learner of mathematics with his childhood development, as he wrote, "So since I was a little kid, I've been around math, learned about numbers, and even made money using math" (Essay). Ericksonian identities provided the boys with psychodynamic consistency over the course of their lives, whilst their Median identities corresponded to what they accomplished through social practices such as school mathematics (Erickson, 1980).

It was apparent that James's past experiences mediated his current mathematical identity when he wrote, "Now, I'm a junior in high school and I still try to bring the same energy into my pre-calculus course as I did during my glory days in "Around the World"" (Essay). The salience of James's positive mathematical identity was encouraged by the role support he received from others, the intrinsic and extrinsic rewards he earned from his achievements, and his opportunity to enact this identity at his present school (McCall and Simmons, 1978).

Edward illustrated the issue of the emotional continuity of his mathematical identity with his autobiographical story:

> When I was in Fourth grade I was considered especially smart and once a week went with a few other students to learn deeper studies. When I was in sixth grade I was a part of the advanced math class, but due to troubles at home, my grades dropped severely. This continued throughout the rest of my school career to the point where I am today. (Edward, Essay).

After receiving accolades in the fourth grade for his knowledge of school mathematics, Edward lost his advantaged position because of his difficult home life. This downward trend continued to characterize the pattern of his school career. Weigert et al (1990) asserted "self is a multidimensional, reflexive, experiential process involving knowledge and emotion shaped by the individual's roles and social position" (p. 42). Due to his changing social roles, Edward constructed multiple versions of his mathematical identity with respect to his corresponding self at each phase (Weigert et al, 1990). Edward's past experiences mediated his present mathematical identity in this manner.

Adam attributed his lack of patience in doing math to being a "teenager" (Interview). By referring to both 'math' and 'teenager', Adam positioned his mathematical identity on a path that paralleled his physiological development. James's preference for the physical and extroverted qualities associated with playing the "Around the World" game, versus his dislike of the sedentary and introspective nature of doing geometric proofs, indicated possible difficulties associated with being an active, growing boy (Essay, Interview).

Raymond discussed math and business together with family and friends (Interview). As part of his personal history, these relationships shaped his mathematical identity. Arthur's individual agency, which overshadowed the expectations of his teacher, mattered in the construction of his mathematical identity. Arthur said that he did not consider sitting in a classroom, listening to a teacher, as "doing something" (Observation). He preferred physical or musical activities to classroom lectures. This suggested that in the past, he rejected the consensual nature of learning, and thus deprived himself of the experience of negotiating mathematical meaning (Voigt, 1996).

Emerging Issues

The previous sections of this chapter systematically answered my research questions, which pertained to the mediation of mathematical and other identities. Weaving my web more expansively, I now want to discuss the larger ideas about identity, struggling teenage boys, and school mathematics that emerged from my analysis. This discussion is structured in accordance with Weigert et al's (1990) five identity issues that I included in my literature review. The purpose of this exercise is not to overextend the boundaries of my study, but to show how my research may contribute to theoretical knowledge, within its methodological constraints.

Subjective and Objective Identity

The "dialectic of subjective and objective identity" is an issue reflected in the strain that individuals experience when negotiating social identities (Weigert et al, 1990, p. 54). In the face of contradictory identity norms, struggling teenage boys developed creative management strategies to stage their performances of school mathematics. Contradictory identity norms exemplified the dialectic between individuals and society, which, for these middle to upper-middle class students, was their nontraditional educational path versus traditional school route. Educational discontinuities sometimes made completing college preparatory mathematics challenging. Identity norms, such as preferences regarding schooling, were based on people's expectations within the boys' social groups (McCall & Simmons, 1978). It was a common occurrence in this non-traditional school setting that the boys had not met the expectations of their families and previous schools, and that discrepancies existed between their social identities associated with school mathematics

and other practices. The word ‘struggling’ provided a name for their stigma (Strauss, 2007). Some boys talked openly about their struggles with math, whilst others did not. Their actions served to communicate particular impressions about these boys (Goffman, 1959, 1986). Nevertheless, in the midst of their struggles, teenage boys employed identities as expressive tools that often held desirable positions for them in school mathematics. In this manner, they negotiated the dialectic of subjective and objective identity.

Availability of Identities

The social identities accessible to individuals at a given time and place is an issue of the “sociohistorical availability of identities” (Weigert et al, 1990, p. 56). As many had lost interest in the academic mainstream, nontraditional courses, such as my Business/Consumer Math, offered struggling teenage boys the opportunity to construct positive mathematical identities, which encouraged their participation in school mathematics. Though all the boys in my study were offered college-preparatory math, some chose not to cultivate their mathematical identities in this manner. The small and nurturing milieu at my school was a fitting setting for me to build their confidence by utilizing a flexible approach. Generally, identity availability depends upon social factors such as time, place, and appropriateness. A traditional school institution may have enforced boundaries or constraints within didactic mathematics classrooms (McCall & Simmons, 1978). Nevertheless, even without customized math courses, rich discussions in the classroom engaged a broad range of mathematical identities (Boaler & Greeno, 2000). Salience was determined, in part, by an identity’s “perceived degree of profitable enactment in the present circumstances” (McCall & Simmons, 1978, p. 82). The possibility existed that a struggling teenage boy possessed positive identities that would flourish if the circumstances

were different than their present situation. To legitimate their desire to improve, struggling students needed opportunities to enact positive roles in school mathematics, which served to increase the sociohistorical availability of these identities.

Multiple Identities

Within social contexts, the "organization of multiple identities" is the issue related to identity management with respect to individual challenges and incentives (Weigert et al, 1990, p. 57). Positive mathematical identities of struggling teenage boys were clustered with compatible social identities that thrived as a result of the intrinsic and extrinsic gratification provided by mathematical knowledge. Clusters of identities formed in conjunction with each individual's effort to gain mathematical skills, and thus encouraged his current or future participation in social practices requiring them (McCall & Simmons, 1978). Whilst intrinsic gratification was suggested by the boys' personal enjoyment of doing math, extrinsic gratification was exemplified by the boys' useful enterprise of doing math. For example, intrinsic gratification was illustrated by aesthetic experiences, such as how math could inspire wonder when one observed it mirrored in the beauty and symmetry of the natural world, as well as the appreciation of effective proportions in architectural design. Within the venue of extrinsic gratification, discussions about money paralleled talk about math. One boy said that simple math skills improved one's ability to manage one's money. It was a common belief that knowing how to do math enhanced one's career prospects in business, science, and engineering. Positive mathematical identities of struggling teenage boys were revealed in conversations that naturally drew out their intrinsic and extrinsic rewards of doing school mathematics. Broadly speaking, in an organization of multiple identities, those that delivered intrinsic and extrinsic gratification

increased in overall salience or relative importance, and thus became more viable (McCall & Simmons, 1978).

Identity Continuity

Another issue, the "continuity of identity" relates to social identities and the passage of time (Weigert et al, 1990, p. 60). Situated in dynamic environments, the mathematical identities of struggling teenage boys were active and expanding. Given their developing nature, mathematical identities resisted permanence (Vadeboncoeur & Portes, 2002). That the boys communicated different mathematical identities in relation to the past, present, and future was consistent with the sociocultural view. For example, some boys had negative feelings about school mathematics when they focused on the past and present, yet these same boys had positive attitudes towards school mathematics when they discussed future-oriented career plans. However, even when they talked about their future plans, self-contradictions were apparent, such as when they articulated mathematics-dependent career goals along with their wish to study the least amount of math possible. The reasons for these boys' desire to "get more for less" were complex, but they sometimes mirrored the boys' difficulties with school in general. Middle to upper-middle class teenage boys appeared to maintain their expectations of mainstream success even though they had experienced failure in traditional academic settings. Concerns about their entitlement aside, the structural elements needed to encourage the continuity of their positive mathematical identities included high salience, role support, and exchange resources (McCall & Simmons, 1978).

Emotions Related to Identity

"Identity and emotions" is a multifaceted issue (Weigert et al, 1990, p. 62). When a struggling teenage boy loses a former identity in school mathematics, it may evoke feelings of shame and mistrustfulness. Endangering trust, the term 'shame' described a painful experience of the whole self that was difficult to communicate (Lynd, 1965). Struggling boys who were once designated as "gifted," but were no longer eligible to take advanced classes in mathematics, illustrated the shame that often accompanies identity loss. This theme was echoed in a boy's story about how he excelled at arithmetic, yet struggled with geometric proofs. In this case, his position with respect to the other students diminished. If shame was not openly displayed, then it may have been evidenced by mistrust, especially in talk about money. For example, one boy emphasized how he always counted his change so as not to be cheated by a shopkeeper. Along a similar vein, when a boy expressed his desire to keep tight control over his personal finances, he communicated his lack of trust in others. Given that at one time many of the boys were treasured young children from privileged backgrounds, the very nature of their chequered academic histories indicated failed expectations and lost opportunities. Stripped of metaphorical content, the metonymic form of arithmetic problems allowed them to achieve mastery in a straightforward way. Struggling teenage boys sometimes mediated positive mathematical identities in these simple math experiences.

CHAPTER 6

CONCLUSION

Introduction

In line with general expectations for qualitative research, my conclusion offers a closing statement for the study, rather than an overarching judgment about its results (Wolcott, 2001). This chapter first presents a summary of the research that I conducted with respect to my original statement of purpose. I restate it here, in past tense, for the sake of clarity: The purpose of my study *was* to gather and describe case studies of 'struggling' teenage boys, focusing on their identities, which I assume are mediated by the discursive practices associated with school mathematics and other activities. I next present a concise account of the study's results, organized around the research questions, and including their limitations within the research design. My four research questions focused on how doing school mathematics mediated the boys' identities. The questions also asked how the boys mediated their identities in school mathematics, along with other social practices and past experiences. A brief section that states how my thesis represents a 'contribution to knowledge' and how it is 'original' follows. Finally, from a reflective and personal perspective, I present the implications for my teaching, the new questions that emerged as a result of doing the study and suggest possible improvements for future work.

Summary Regarding Purpose

Accomplishing my original goal, I gathered and presented descriptive case studies of seven struggling teenage boys. These 'struggling' boys ranged in age from sixteen to eighteen, and represented a wide variety of personal backgrounds. The purpose of the case studies was to describe the boys' mathematical and other identities, which, given the sociocultural

nature of the study, placed the goal of description at centre stage. These descriptions were well grounded in a theoretical framework, applicable to my work as a mathematics teacher at a small boarding school for boys, the setting for my investigation. Fitting to my own work at a supportive school, the sociocultural approach placed importance on an individual's actions and mediated identities within a community of practice.

For the descriptive case studies, the unit of analysis was mediated action, a strategy of negotiation in the dialectic of society (Wertsch, 1991). The description of the unit of analysis in the study was the person acting with mediational means. For my study, mediational means were social identities, associated with lived practices at various times and places. I appropriated a working theory based on Wertsch's (1998) "*Ten basic claims*" about mediated action, which I synthesized with the structural and emergent properties of identities (p. 25). In erecting this theoretical framework, I wanted to develop an approach that I could use to document and inform my work at my school, as well as offer insight to similar situations at other institutions.

Some of the properties of identities that I used in my study came from Goffman's (1986) work on stigmas, McCall and Simmons' (1978) salience hierarchies, Willis's (2000) ideas about the body's role in expressing social identities, Lynd's (1965) work on shame that shed light on the emotional aspect of identity, and Shaw's (1994) notion of identity as a signifying practice. The studies I reviewed that related to mathematics education and identity were Barnes (2000), Boaler and Greeno (2000), Lave (2003), Walkerdine (1990), and William, Bartholomew, and Reay (2004).

With a view towards the boys' mathematical and other identities, my own research design had a methodology that called for collecting qualitative data on individual boys, and then matching it, in a table, to Wertsch's (1998) "*Ten basic claims*" about mediated action (p. 25). The data that appeared in the boys' individual tables was drawn from their personal information, student-authored essays entitled *My Experience with Math*, my classroom observations, and interviews. I then extracted this data along with the appropriate "*claims*" in order to 'answer' the four research questions (Wertsch, 1998, p. 25). I also linked the data to the identity literature. These discussions, which I structured around the research questions, comprised a rich descriptive report.

Results of the Study

What follows is a condensed account of my results, with attention given to their limitations in the next section:

How doing school mathematics mediated the boys' identities: The boys had multiple discontinuities in school attendance, which I associated with structural tensions in their mathematical identities. There may have been a stigma attached to their deviation from the norm since secondary school mathematics programs generally expect continuity, and a curriculum that builds upon itself. Institutionally-imposed identities assigned to the boys arose from low grades and standardized test scores. Some of the boys had abandoned a college preparatory math progression and were studying an alternative course called Business/Consumer Math. On a positive note, new experiences with school mathematics facilitated new mathematical identities, whether offered inside or outside the classroom. The boys individually appropriated school mathematics to suit their interests and learning

styles. Ways of doing math included classroom learning activities, studying with an individual tutor, and simply looking it up in a textbook. The capacity to use math was perceived as important by almost all of the boys.

How the boys mediated their identities in school mathematics: The boys' mathematical identities reflected various characteristics of doing school mathematics such as rigour, competition, acceleration, precocity and carrying out abstract practices. With regard to school mathematics, some of the boys assumed a defeatist stance, which they communicated through disinterest. Negative statements indicated their not wishing to progress beyond arithmetic, as did mood-dependent performance, extreme dislike of lectures, and clinging to an identity as mathematically 'gifted' even in the face of poor grades. Reliance on assumed talent was used by a few of the boys to justify not doing school work. These same boys exhibited positive mathematical identities as well. Almost all the boys' mathematical identities related to post-secondary education and a future career, as well as to certain tasks in adult life. The boys' career identities included engineer, businessman, music executive, graphic designer, and marine scientist. The boys stated that mastery over mathematics was an important aspect of realizing these future identities. They associated mastery over math with fondness for math. Some of the boys expressed confidence, and boasted about their math abilities. When discussing math, one boy thought that he had already learned everything that he would ever need to use in real life.

How the boys mediated their identities in school mathematics and their identities shaped by other social practices: Along with their mathematical identities, the boys managed clusters of social identities. It appeared that their mathematical identities were compatible with their

identities based on future careers, since they believed that it was important for them to study math in order to succeed. At times the boys contradicted their own plans. This was expressed in their wish to study the minimum amount of math, or to avoid certain aspects of the discipline that caused them frustration. It was clear that the boys associated math with exchange resources such as money, knowledge, and sources of power and authority that included magic, God, and the universe. One boy discussed math in conjunction with good design. I related the boys' mathematical identities to their identities associated with physical movement such as kickboxing, surfing, snowboarding, skateboarding, and weight training, as well as team sports. One boy told how he enjoyed a game, designed to practice math skills, which involved moving around in an elementary school classroom. Some boys enjoyed math-related tasks that required hands-on work, such as building a grind box that required cutting and measuring of parts, and volunteer water sampling work at a marine research laboratory.

How the boys' past experiences mediated their present identities in school mathematics: The boys' progress as learners of mathematics paralleled their development as growing children. They mediated their present mathematical identities in their childhood experiences of using numbers. One boy described his glory days playing an arithmetic game in an elementary school classroom. Another boy recalled his identity as a high achiever in math, only to lose this distinction because of family problems at home. Believing that he lacked patience one boy attributed his poor performance at math to being a teenager.

Limitations of the Study

It is important to note that I cannot generalize the results of my study to the population of all 'struggling' teenage boys, nor can I establish causal relationships. I can only generalize my case studies to the descriptive theory that I developed before conducting the study. This descriptive theory is the working theoretical framework, in which I synthesized Wertsch's (1998) "*Ten basic claims*" about mediated action with the structural and emergent properties of identity. In my view, the results of my case study research provided evidence of a sturdy link between the data and the theory. The seven case studies contained data that was characterized by variety and diversity, a property more noteworthy than the number of cases that I studied (Kennedy, 1979). A broader generalization process is facilitated by the variety of characteristics included in the data. This was reflected in the richness of the data tables for the individual cases. The data in the tables looked fresh, as it remained in the boys' own voices, both spoken and written. With respect to qualitative research, this approach of presenting the data free of interpretation is a desirable aspect of my methodology (Willis, 2007). Whilst patterns existed across the individual cases, I cannot draw conclusions from analyzing them (Fetterman, 1998). Nevertheless, this work served to reveal the complex nature of the boys' mathematical and other identities, and thus helped me to understand them better.

Original Contribution

My study is original for its sociocultural focus on the mathematical and other identities of struggling teenage boys within the setting of a small nontraditional school. Contained by its methodological constraints, my thesis makes a 'contribution to knowledge' in the issues that it raises about identity, struggling teenage boys, and school mathematics. I summarize these matters in reference to Weigert et al's (1990) five issues about identity as follows: To

negotiate the dialectic of opposing identity norms, struggling teenage boys employed identities as expressive tools that held desirable positions for them in school mathematics. In the organization of multiple identities, salience depended upon the intrinsic and extrinsic gratification associated with knowledge of mathematics. It appeared that positive mathematical identities clustered with compatible social identities that were also supported by these rewards. That the sociohistorical availability of identities increased was evident in the nontraditional mathematics courses that provided the boys with opportunities to enact positive roles. Many of the boys communicated positive attitudes towards school mathematics in relation to their future career goals. Though they may have struggled in the academic mainstream, they expected to achieve conventional success in the adult world. The issue of identity and emotions was illustrated by the shame and mistrust that accompanied the loss of a former identity such as a "gifted" level in school mathematics. For some struggling teenage boys, mistrustfulness was evident in their discussions about money. Interesting to note was the affinity they expressed for simple arithmetic, which they could easily master with repetitive practice.

Emergent Questions, Potential Improvements, and Implications for Teaching

Moving beyond my study, the emerging questions concern how I could exploit my theoretical framework and research approach for educational purposes in a school setting. In my experience, 'struggling' teenage boys generally have emotional/behavioural diagnoses, which are based on previous testing. Former school transcripts and standardized test scores are also sources of information about past performance. However, in my day-to-day work with these 'struggling' students, I have found that the factor most visible and relevant to their classroom work is their identities associated with mathematics, as well as

their other interests and relationships. This is especially true in a small learning environment that offers support to ‘struggling’ students.

My methodology calls for collecting personal data, interviews, and essays, which are all entities that reflect the learner’s current situation. In my study, this methodology provided well-grounded descriptions of the boys’ mathematical and other identities. My question is, how could these individual descriptions of identities be used to guide instruction in contexts that extend to the virtual world? One possibility is to use this information to build bridges with discussion topics that engage the learner’s multiple identities, as well as his mathematical identity. Boaler and Greeno (2000) observed that learners of mathematics in discussion-oriented classrooms used “*more* of their selves” (p. 189). Transference of such information about a student’s behaviour occurs verbally between teachers, but may not appear in a ‘struggling’ student’s learning profile. In this respect, I think it would be desirable if qualitative data were used to balance the quantitative data from sources such as standardized tests.

For my methodology, potential improvements to my research could increase the characteristics of the data by including participants from other socioeconomic groups. Broadening the study to include girls is also an alternative, though not conducive to use at my school, which only accepts boys. Another question is, how could learner identity profiles be used to inform educational practice in contemporary learning contexts? Following van Oers (1996), I consider school mathematics a sociocultural activity in which mathematical identities form within social interactions and textual productions. Pedagogy, based on sociocultural ideas, views the learner as an active participant in various contexts,

inside and outside the classroom. With regard to school mathematics, the answer to my question may lie in systematic documentation of the efficacy of an individualized approach in getting 'struggling' students to participate, thereby encouraging them to construct positive mathematical identities.

Important to my teaching was how my students' motivation often increased as a result of their participation in activities that provided them with opportunities to enact positive roles in school mathematics. A boy using mathematics to solve problems whilst volunteering at a marine research laboratory was an example. Regarding the individualized design of a school mathematics curriculum, I noted that the themes of 'useful' and 'money' resonated with many of the struggling teenage boys. Customized courses, such as my Business/Consumer Math, appeared to encourage struggling learners to construct positive mathematical identities within clusters of social identities that were empowered by mathematical knowledge and skills. Given that mathematical skills are vital to success in business, one boy's plan to found his own music production company in which he would assume the role of CEO illustrated how future career identities cohered with mathematical identities. In my own professional practice, cultivating these future-oriented identities presents an exciting opportunity in which to promote struggling learners' mathematical identities.

Research findings linked to school contexts increase understanding and provide a basis for making decisions. As a result of my experience, I am keen to promote mathematics attainment through research-based teaching and leadership practices. Willis (2007) advocates for communicating "phronesis" to others, whilst referring to Aristotle's term for

knowledge gained in a particular setting (p. 120). Merging my roles as researcher, teacher and school leader, I endorse collegial conversations that focus on conducting research and discussing its implications for teaching. Compassionate educational leadership involves making a scholarly effort to understand learners' individual circumstances and inspiring others to share in the effort. My endeavour to study mathematical and other identities of struggling teenage boys illustrates how equity in mathematics education is likely supported by professional development that contains a strong research component.

APPENDIX

Interview with Tyler

M: My impression (from the essay) was that you are interested in the intellectual part of math, the big ideas, would you agree with that?
T: Mostly, yes. It's all intellectual.
M: So, you haven't had a very good experience with math, would you agree overall?
T: Well, I never liked it that much.
M: When did you first realize that you had some difficulties with doing it?
T: I had it all figured out until algebra, which is basically like learning another language.
M: Do you ever see yourself using math down the road in some sort of career?
T: Not really.
M: Do you have any interest in any particular career?
T: Not yet. No.
M: How did your dad like math?
T: He wasn't very good at it.
M: He told me the story about getting a D. Can you repeat that?
T: Oh yah. One of his professors put a minus sign that extended all the way across the paper on his D-minus.
M: But he passed the class, but just barely! What about your mom?
T: I don't know anything about her academics. She's pretty intelligent, so I'm sure she could figure it out.
M: So you see math as a language?
T: Yes, I do.
M: Do you see yourself studying math beyond high school?
T: Probably not.
M: Can you remember any math teacher that you had before me?
T: Yes.
M: Who was that?
T: Mr. Mellon in seventh and eighth grade. Before that I think that math was just something that your one teacher taught you.
M: Yes, right, a classroom teacher. Now when you got to seventh and eighth grade, what did you think of the math teacher?
T: He was a pretty funny guy and kind of like a computer geek type of guy, except with a sense of humour (pause) that targeted those that were not very good at math.
M: Describe a person who is good at math.
T: Einstein, he is pretty much the classic example, right? He's good at math. Einstein's good at math.
M: Can you think of a profession right off the top of your head that would use a lot of math?
T: Engineering.
M: Have you ever met an engineer?
T: No.

Interview with Adam

As I am starting my tape recorder, Adam is telling me that he does not like math.

M: Tell me why don't you like math, Adam. You just said that you didn't like it.
A: I guess I don't really like it because it's really time consuming, and I mean, being a teenager myself, I guess I don't really have the patience to do it (pause) and I've never really been good at it. I guess it will be something that I'd like to learn more how to do, and do it more frequently, so that I can become better at it.
M: So would you think it conflicts with how you are as a teenager?
A: Not really. My social life is not really affected by math or nothing like that.
M: So math isn't something that helps your social life any?
A: Not really (chuckle).
M: What about reading the *Wall Street Journal*? That is something that I have encouraged you to do and it doesn't seem that you enjoy it very much. Any particular reason why not?
A: Well, I like to read. That's one thing that I like to do. But there are some things in particular about politics and government that don't really interest me. But I guess if it was a section about music, or something like that, I would be interested.
M: Do you see yourself using math in a potential career?
A: Oh definitely, probably a field of mechanics like engineering, something like that, something where I could use my hands.
M: Is that what interests you?
A: Yes, building things.
M: That's what you'd like to study?
A: Yah.
M: So you definitely see yourself using math after high school?
A: Yes. So I'd like to get better at it, but things take time, especially math.
M: Compare algebra to geometry –your experience with it.
A: I guess I like geometry more because it has to do with shapes and things like that rather than just numbers and stuff. I mean things with angles and stuff are always fun to find out what the answer is.

Interview with Raymond

M: Why do you bother to study math, what's in it for you?
R: I don't know. I'm good at math so I kind of like it. It's one of my favourite subjects, and also to get a good grade in another class to get into college.
M: Why do you think it's easy for you?
R: I don't really study it. I feel that it just comes to my head easily and I don't study that much at home. I just felt like I knew how to do it. Numbers come easy to me.
M: Did you realize that when you were in elementary?
R: Yes. In second grade my mom realized that I was really smart so she got me tested for a gifted program, which is an advanced program. I got like a 97 in math and 92 in reading and so I moved to gifted in third grade and just stayed with advanced classes until 7th grade.
M: Do you think that math is something that you would like to continue to study?
R: Yes, it will be good for me in the long run, I think, to know math.

M: Is there any particular career that you are interested in?
R: Business, I'd like to work in something to do with business with my brother.
M: Is he majoring in business?
R: He is. Yah. And he is thinking about moving to where my step-dad has a close friend, who owns a business and is a multimillionaire. He is going to take my brother in and give him a job.
M: Did your parents like math?
R: Well, my dad didn't get the best grades and I don't think my mom did either. I don't know. I don't think that either of my parents were that good at math.
M: Is there any particular area in math that you liked more than others?
R: I like Algebra, I'm good at algebra. I'm pretty good at geometry too, if I just pay attention to it.
M: So what do you think knowing math enables you to do?
R: When you buy stuff in stores they can rip you off. They can give you the wrong amount of money and if you know math, you realize – *wait*, this is not the right amount of change, which for some reason I always think about when I buy something. I never just take the money and just walk out. I always look at it, count it, and realize how much money I paid for it.
M: Can you think of somebody in particular who is good in math?
R: Well my brother is good at math. Yes, he's really good at math, and my best friend is.
M: Do you think there is a relationship between being good at math and being good in business?
R: Yes, a big relationship. You need to know a lot of math to have a business.

Interview with Edward

M: How did you do in math in the first few courses that you took in high school?
E: I did well when I tried. I mean, I came out with Bs and Cs when I decided I wanted to pay attention in class and do the work, but I also came out with some Fs and that's when I just wanted to sleep and do crossword puzzles and stuff. So it kind of differed on my mood for that quarter or semester.
M: Did you find the math interesting?
E: Some of it. I guess more the math that I could use – even later that day. Oh yes, I learned this in class, I can use it in this math problem to figure out the answer. That was interesting, but some of the stuff like to use a recent example like complex numbers. I mean it's interesting, but only to a certain extent because you know you're really not going to use that when you are 30 or 40 or something.
M: Now you are interested in science, in pursuing a scientific career.
E: Yes.
M: So do you see math as part of that?
E: Well obviously, because science and math cohere, go hand in hand. But, I'm going to try and get away with doing as less math as possible.
M: How did you use math in the problem you worked on at the lab?
E: It was basically like 50/50 with doing math and actual science, because to take the sample we had to do all the measurements of the instrument that took the sample, then calculate the distance of the water sample, then calculate the volume of all the water

samples, and then the sub-samples. Then once all of the organisms in the sample were identified, I guess, calculate those into all the sub-samples to see kind of the broad view of how many organisms are in the surrounding waters, and also taking filters of samples to see how many organisms create a dry weight on a filter to get another spectrum idea of how many organisms are in the water. It's all on the basis of using a small amount, and getting that information, and multiplying it to find out what the broader view is.
M: Did you need assistance with that effort?
E: Yes, sometimes. I mean more along the lines that I needed assistance with where to plug the things in the microscopic *Excel* program that we were using, and not really along the lines of how do I solve this equation, but more like where do I put these numbers.
M: Did the research scientist set up the spreadsheet before you started working on it or did you have to set it up?
E: I guess I had to set it up. They kind of watched over me and answered any questions I had.
M: So you did it semi-independently?
E: Yes, a few of the times that I went to the lab, I basically did everything by myself. I went to the lab, got the instrument, walked to the dock, took the sample, and came back up and then plugged all the things in without talking to anyone or asking for help.
M: Did you like that independent way of learning?
E: Yes. I liked it. I guess more from a standpoint of self-gratification from knowing how to do everything already without having somebody tell me how to do it or tell me the steps. Like me already knowing how to go and take a sample and then do sub-samples and then look in the microscope and tell which organism is which. Just kind of doing all that gives me a sense of self-gratification and that is a lot better than having somebody help you step by step, I guess you knowing that you've already learned it.
M: Think back in terms of learning math. Were most of the classes lecture-based?
E: I would have to say that most of the classes that I took were note-driven. The teacher would write down notes either on a projector or something of that sort and then we would copy it down and then basically they would say if you don't know how to do it then look over your notes. If you read the notes it will show you how to do it. Then they would give us tests on the notes.
M: Did they interact with you?
E: Yes, if we had questions, they would try and explain it to us to a certain extent. You also got to remember that if 10 kids in the class don't know how to do it in a class of 30 kids, then just those 10 kids kind of tune out while the other kids that care about getting answers to the questions get help and move on.
M: I want you to talk about math in terms of rules. How do you respond to all the rules?
E: I guess because I'm the kind of person who doesn't respond to authority well, and in a lesser sense, rules, I kind of like to do things on my own, and in my own way. I guess math is not that bad because the rules often times help you in being able to solve the problem. They keep you organized and keep you on track. When the rules weren't there you could easily get off track and lose your train of thought and lose what you are doing. I guess the rules are more of a guideline than a kind of overbearing force that is trying to keep you strict or something. So I guess the rules are kind of like a tool to help you, or that's how I view them, instead of someone giving you rules and you have to follow them to be good. I mean the greatest mathematicians figured out problems doing something a little abstract.

Interview with James

M: What math classes did you take before you came here in high school?
J: The two maths I took were Geometry and Algebra II.
M: How did it go for you?
J: Geometry went well. I was pretty good at Geometry except I could not get the proofs down so I ended up failing a couple of tests and ended the year with a C+.
M: So the proofs were difficult for you?
J: Yes, they were pretty easy for everyone else, but for some reason I could not understand them. And it was the same in Algebra II. I had a pretty good grade for the whole year, but there were two pretty big tests. One was a chapter test and the other was a final and it had a big proof on it with theorems and axioms and stuff like that.
M: Do you specifically remember what the topic was?
J: Well it was in Algebra II. It was identity axioms and stuff like that. You know, multiplicative identities and stuff like that. The thing of it was, it was actually my entire final and I ended up getting twelve points off for not knowing the proof.
M: Did you study that material in a different sort of way than you studied other things?
J: It seemed like such a ridiculous thing to study. And plus not only did you have to learn all the theorems and axioms, and there were thirty something and you had to learn all of them, you had to know exactly how to apply them in a certain situation. I understood the example proofs, like they would have a proof of a certain equation, but then on the test you would have different equations and stuff like that. There was just no way I was going to recognize it so a lot of times I would guess on the test and end up getting a pretty miserable grade.
M: So do you like the applied math better than the pure theoretical stuff?
J: Yah. Definitely.
M: What part of math do you find most interesting?
J: I think when, at least last year and sometimes this year, we would always throughout every chapter learn something and at the end of the chapter they would have this real world application. Some of them were stupid like when you would be given the y-intercept. For example, say Jimmy hits a baseball and he holds it above the ground four feet and he hits it and it lands a certain distance away after a certain amount of feet and what was its maximum height? So what was the vertex of the parabola or whatever? I always liked those problems and those are pretty stupid examples, but they have others, ones for car insurance rates that I always thought were kind of interesting, and the really simple ones in geometry. It would be like you have a certain amount of fencing to build for a pig pen and you want to maximize the area or whatever and it would give you the length of one side and you would have to find the rest.
M: What was your family's attitude towards math?
J: Well, my dad was really good at math, so I think he always liked math. I mean he majored in art history in college so it's not like he did anything that serious concerning math in college, but I guess that helped him when he went into business, and then my mom hates math, and neither of my sisters are really very strong in math either.
M: It's interesting what you say about proofs. How was that material different than other material?
J: I don't know. It didn't feel like math to me. I like the idea of there being a set of rules that are always applied, but at the same time, I think that I'm more able to function with a problem that concerns all numbers and getting a solution, than trying to find out why one

set of numbers becomes another set of numbers or some mathematical property. I mean the proofs are concrete, but it doesn't seem like it is when you're doing it.
M: Do you want to study math in college?
J: Yes. I don't know about all the way through college. I'll take a couple of courses.

Interview with Arthur

M: You had said to me (in class) that you didn't think that you were going to use any of the maths in real life.
A: No.
M: You don't think so?
A: No.
M: Nothing?
A: I know my plus or minuses and that's all I'll ever really use, if I need it.
M: When you wrote your essay for me, you said you used math for music.
A: Oh yes, just 1, 2, 3, 4. I don't need to know a lot of complicated stuff.
M: Can you give me an example of how that might work?
A: How I use math in music?
M: Yes.
A: Well yes, sometimes in a lead-in I have to put 16 notes into 8 bars, but that's about as complicated as it gets. Just simple math, I don't need to know 'x' minus 'b' equals 'c'.
M: Any topics from business math that you find interesting?
A: Yes.
M: Like what?
A: Money.
M: Okay. Any specific examples of that?
A: No.
M: What do you think the ideal math class would be in high school?
A: None.
M: How old were you when you think you learned enough maths?
A: Third grade.
M: Yah?
A: So there's nothing new.
M: What kind of math did you take at your former school?
A: I don't remember.
M: What about when you go to music school, do you think you'll have to study any math?
A: Just simple math, I mean that's all I really need to know, and I'm not going to waste my time with algebra.
M: Yah?
A: But I'm not, so it's working for me.
M: So you like it (Business Math)?
A: Yah.
M: You said (in class) that you wanted to learn about money and banking and the economy, so that's what we've been doing, right?
A: I've listened to what we've been reading about banking. I figure I handle my money better than any banker can. So I won't ever need one.

M: Are you interested in investing?
A: No.
M: What would you do with all your money, if you had a whole bunch of money?
A: I would just sit on it and use it for small things.
M: Real super secure?
A: Yes.
M: Fixed rate of return?
A: Yes. I wouldn't let anyone else handle my money. Once I start making money, it's going to sit right next to me.
M: What about spending money?
A: I'm going to spend it, but then I make it.
M: So what do you want to do for a career?
A: Just make music.
M: Any particular kind of music?
A: Hip Hop (pause) making instrumentals.

Interview with Jack

M: Do you think you're going to have to take a math class in college?
J: Yes. I have to take the course called College Math and I have to get my textbook when I go for their open house.
M: Okay.
J: And one of the math courses is online too. The math course has to do with design.
M. Do you see yourself using math to do design work?
J: Of course. With dimensions and shapes.
M: Have you ever done that before?
J: Not to the extent I'm going to at college, but I've done it with building. I've drawn up blueprints for a grind-box for skating. I used dimensions.
M: So you had to cut and measure?
J: Yes.
M: Is that the math that you like to do best?
J: Yes. Hands on. I like just doing it, the whole deal.
M: Do you ever incorporate any colour?
J: Oh yes. I love colour. I think the use of colour is what makes or breaks the image. Well it depends on if you want it to stick out, you need colours.
M: What about proportion? Have you ever hit any measurements that you feel work well?
J: I like making stuff big (pause) really in your face. I like to do more detailed things. When it's smaller you can't hit as many details. You have to preserve space. When it's big you can go to town and have fun.
M: Did you like Geometry?
J: I did *good* in Geometry, it was the shapes and designs and stuff.
M: Can you look at something and know that it is a good design based on its proportions?
J: Yes, I do that all the time with buildings. Well, I like the way it's laid out, the floor, the ceiling height.
M: What about cars?

J: I do that with cars all the time (pause) looks like a box, too boxy; I like the lines, makes it look real sleek, fast when it's actually standing still. Design's everywhere. It's crazy. That's why I'm so interested in it.
M: So applying math to design and proportions is something that interests you?
J: Yes, because you'll never run out of that. If you think about it nobody will never not need a graphic designer, because graphic design and advertising is everywhere. It's crazy.

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