THE RELATIONSHIP AMONG LANGUAGE, CLASSROOM DISCOURSE, COGNITIVE DEVELOPMENT, ACHIEVEMENT, AND VOCABULARY OF DEVELOPMENTAL MATHEMATICS STUDENTS

A DISSERTATION

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degree of

DOCTOR OF PHILOSOPHY

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APPROVED FOR

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ABSTRACT

The purpose of this research was to examine how focusing on language and classroom discourse impacts the cognitive development, achievement, and vocabulary development of college developmental mathematics students. Two classes of basic algebra students were used in this quasi-experimental study. One class served as the control group and the other the experimental group. The experimental treatment was journal writing, which consisted of writing prompts about vocabulary and concepts specific to the algebra course. Three instruments were used for pre- and post-testing to study the relationships between the variables. The Scale of Intellectual Development – IV measured cognitive development based on Perry's model. The College Placement Test (CPT) measured student achievement. A researcher constructed vocabulary test measured vocabulary development. Student evaluations of the journal writing process were also used to add a qualitative component to the study.

According to the results of quantitative and qualitative analyses, the journal process impacted specific interest groups differently. The females in the experimental group indicated that through the production of more complete journals, that they received a greater benefit from and attributed more value to the exercise than the males. By reviewing the journal evaluations written by the students, it was apparent that the males felt more comfortable defining terms in their own words, while the female students did not enjoy this part of the exercise. Students who were dualistic stated that they did not like that answers to all the questions could not be found in the text. The dualistic students copied definitions from the text, while students with cognitive development beyond dualism were able to paraphrase the meanings of words. The freshmen in the experimental group also had significant results from the journal writing exercise, including an increase in achievement and a significant change in both cognitive development and vocabulary development. The nontraditional students in the control group were able to increase their vocabulary development without the use of journals. The independent. self-motivating nature of nontraditional. adult students may have influenced this result. The results of this research should be further explored.

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Chapter I

Introduction

Language use is crucial in learning. It is employed to communicate and make sense of our experiences. According to Vygotsky, communication is a process of constructing and interpreting signs (1962). There are many signs, such as words or gestures, which compose language and carry information. The purpose of this study is to examine the impact of students' deliberate efforts to define and articulate mathematical concepts on their mathematical understandings. Language use and meaning will be explored across gender, cognitive development levels, and traditional vs. nontraditional categories for differences in students' use of language as an indication of their understandings of mathematics.

Two of the leading mathematical societies have published their perspectives on the relationship between language and intellectual development. The American Mathematical Association of Two Year Colleges (AMATYC) Crossroads in Mathematics (hereafter the Crossroads) recognizes that communication is important for intellectual development (1995). The Crossroads declares that mathematics faculty should adopt instructional strategies that develop both oral and written communication skills and should incorporate interactive and collaborative learning. The Crossroads promotes instruction in developmental mathematics that provides opportunities to assist students in acquiring the ability to read and write, listen to and speak about mathematics. These abilities require an understanding of language and are the defining elements of literacy. The Crossroads proclaims that students taking a developmental math class should learn how to use appropriate vocabulary and notation to communicate mathematical ideas and become mathematically literate. In achieving mathematical literacy, one should acquire an understanding of the signs, symbols, and vocabulary of mathematics.

The NCTM Standards (1989) also suggests that mathematical literacy is accomplished when students engage in the activities of reading, writing and discourse about mathematics. As students become literate in mathematics, they will be more likely to understand mathematics as opposed to thoughtlessly grinding out answers.

Widespread concerns involving or focusing on gender and nontraditional students exist regarding the learning of mathematics. Several researchers have found a significant decline in positive attitudes toward mathematics for female students over their secondary school years (Brush, 1985; Eccles, Adler, Futterman, Goff, Kaezala, Meece, & Midgley, 1985; Eccles & Blumenfeld, 1985; Fennema & Sherman, 1978; Gutbezahl, 1995; Hyde, Fennema, Frost, & Hopp, 1990; Leder, 1990; Meyer & Koehler, 1990; Reyes, 1984; Stodolsky 1985). A decline in achievement in mathematics has also been significant for females when compared to males (Beller & Gafni 1996; Fan, Khen, & Matsumoto 1997; Sherman & Fennema 1977; Fennema, 1985; Hodges & Nowell 1995; Hyde, et. al, 1990).

Some studies however claim that the gender gap seems to be narrowing with respect to both attitudes and achievement (Brophy, 1985; Freidman 1989; Hayes & Slate, 1993; Hyde, Fennema, & Lamon, 1990; Marsh, 1989). The differences measured between genders may be attributed to the fact that mathematics is believed to be a male domain (Eccles, Jacobs, & Harold; 1990; Fennema & Sherman, 1978; Gutbezahl, 1995; Hyde & Jaffee, 1998; Koehler, 1990; Leader, 1986; Sax 1994; Tarte & Fennema 1995). Several researchers believe that social and cultural factors are responsible for the gender gap in mathematics (Badger, 1981; CME, 1986; Fennema, 1985, 1996; Hyde & Jaffee, 1998; Koehler, 1990; Leder, 1990; Reyes & Padilla, 1985). Fennema (1996) suggests that modifying the environmental factors that influence existing gender differences in mathematics participation and achievement can provide justice and equity in mathematics education. Baxter-Magolda (1988) states that females participate in mathematics by being reflective learners while males participate by being active oriented learners. Since language is a social construct, defined by the constituents of the community of which it belongs, language can be a factor influencing gender differences. Due to the reflective nature of journals, they can be used to access the language of the mathematics classroom. This research investigated any differences in genders that were present after a journalizing process was implemented to increase language development, thus potentially affecting achievement.

Kasworm (1990) defines the traditional student as that person who is 17 – 22 years old. Therefore, nontraditional students are defined as adult students over the age of 22. Research on nontraditional students is not as prevalent as research on gender and mathematics students, despite the fact that, in 1990, a nationwide survey of all types of institutions indicated that 6 million nontraditional students were studying for college credit each year (National Center for Educational Statistics, 1992). This number included 45 percent of all undergraduate students. The nation's community colleges service most of the nontraditional students (National Center for Educational Statistics, 1992). Despite the lack of research on mathematics learning for college students at the university level, there is a wealth of research characterizing this population at the community college level (Baker, 1998; Boss, 1985; Cohen & Brawer, 1996; Davidson, 1989; Governanti & Clowes, 1982; Mickler & Zippert, 1987; Luzzo, 1993; Miglietti & Strange, 1998; Shively, 1989; Smith & Vellani, 1999; Winter & Harris, 1999).

The literature on nontraditional college students characterizes adult learners as independent, practical, and oriented toward experiential modes of learning (Ashar & Skenes, 1993; Bamber & Tett, 2000; Brookfield, 1988; Cross, 1981; Darkenwald & Merriam, 1982; Dill & Henley, 1998; Kasworm & Pike, 1994; Knowles, 1980, Long & Ulmer, 1989; Miglietti & Strange, 1998; Spitzer, 2000). This drive for independence and practical assessment of current skills motivates the returning adult to participate in remedial level courses to renew basic language and computation skills (Miglietti & Strange, 1998).

Several researchers have investigated the construction and effects of a positive learning environment for all adult students including traditional and nontraditional college students. They conclude that the environment can be affected by following prescriptive practices such as responding to the purposes and needs of the learners (Apps, 1991; Hu 1985; Hughes, 1983; Knowles, 1980; Lawler, 1991; Meadors 1984; Seaman & Fellenz, 1989), recognizing the diversity of the learners (Barer-Stein & Draper, 1993;

Fisher & Sartorelli. 1992; Galbraith. 1991; Knowles. 1980; Lenz. 1982; Nelson. 1996; Seaman & Fellenz. 1989). and encouraging active learning (Brookfield. 1988; Borzak & Hursh. 1979;Galbraith. 1991; Knowles. 1980; Silberman. 1996). Research also shows that the adult learner. non-traditional student. progresses in cognitive development more readily than the traditional student due to their greater culmination of past experiences (Cameron. 1984).

In this study. journals were used to promote a positive learning environment by facilitating classroom discourse. to access academic needs and cognitive development of both traditional and nontraditional students. and to renew the basic language of mathematics. How journals may address the need of older students and females will be explored as language use is encouraged.

Language is important to learning because of its connection to thought. communication. and knowledge. We use language to organize our thoughts and express our ideas. which are essential functions of knowledge development and communication. One way of communicating our thoughts and ideas is through writing. Writing causes a deliberate structure of meaning and promotes reflective and generative thought (Emig. 1997). Therefore. writing was chosen as the experimental treatment in this study.

Theorists (Vygotsky. 1962; Mead. 1934; Code. 1991; Bruner. 1983; Lemke. 1990) have investigated a connection between language and cognitive development. Vygotsky (1962) views language as a social construct because it is learned through social interactions. Vygotsky posits this social interaction necessary in the development of language and thought. since cognitive development is the result of social interactions within our environment. Literacy leads to higher-order cognitive skills (Vygotsky. 1978;

cited in Gee, 1996), which implies a connection between language and cognitive development.

Mead (1934) likewise, suggested language is a fundamental tool for communication with one's self and within a social group. Language is the symbolization of thought that is both private and public. Signs constitute language, including words or gestures, which are attached to ideas that comprise our experiences. According to Mead, language is constituted by gestures or behaviors and connected to experience since it plays an extensive role in the development of symbols and their meaning.

Code (1991) agreed with both Mead and Vygotsky that language is specific to a social community. "They [languages] show what objects, events, and experiences a linguistic community considers worth naming and how that community constructs the relations of objects and event to one another"(p. 58). According to Code, language is andocentric, it hinders the translation of experiences to knowledge for women. How the language of mathematics may perpetuate inequities between the sexes is implicated and explored by some feminist researchers.

Previous feminist researchers (Bruffee, 1986; Burton, 1992) have examined the importance of language to concept development at various levels. Some of the research has been specific to the college level developmental classroom (Chapmaigne, 1982; Hayes, Stahl, & Simpson, 1991; Pallman, 1982), while other focused on elementary students (Earp & Tanner, 1980; Linville, 1976; Willmon, 1971) and secondary algebra students (Mayer & Brause, 1983; Nicholson, 1977; Richards, 1990). Common to this research is the idea that taking ownership of a concept requires that one be able to relay that concept through language, which entails associating that thought with a word or phrase. Therefore, in mathematics there is a need for learning a specialized vocabulary, as well as a need to redefine existing vocabulary, in order to communicate ideas and concepts (Greenes, 1995). As concepts become more complex and abstract, new words and phrases must be constructed and associated with these concepts. Bruner states that "the need to use language fully as an instrument for participation in a complex culture…is what provides the engine for language acquisition" (Bruner, 1983, p. 173).

Current research has concluded that there is a connection to the learning of mathematical vocabulary and achievement for junior high students (Bradley, 1990) and intermediate algebra students at the college level (Miller & Smith, 1994). This research will explore that connection for students at the basic algebra level, which bridges the gap between the previously mentioned levels.

Previous studies (Chapman,1996; Cobb & Yakel, 1998; Ford, 1990; Hoffman & Powell, 1989; Johnson, 1983; McNair, 1998; Mett, 1989; Miller, 1990; Vukovich, 1985; Waywood, 1994) identified some aspects of journal writing and discourse that impact the learning of mathematics. Several studies (Borasi & Rose, 1989; Burton, 1995; Di Pillo, Sovchik, & Moss, 1997; Harchelroad & Rheinheimer, 1993; Miller & England, 1989; Nahrgang & Petersen, 1986; Pallman, 1982; Pugalee, 1997; Countryman, 1987) have investigated the therapeutic effects from journal writing as well as a cause for deliberate structure of meaning by prompting students to make connections between past and present material. According to Bell and Bell (1985), Fennell and Ammon (1985), and Harchelroad and Rheinheimer (1993) journaling has been beneficial in the improvement in learning and problem solving. It has also been instrumental in the self-evaluation of students' beliefs about mathematics (Dougherty, 1996; Miller & England, 1989;

Stempien & Borasi, 1985) and in the promotion of discourse and positive classroom atmosphere (Borasi & Rose, 1989; Di Pillo, Sovchik, & Moss, 1997; Dougherty, 1996; Miller 1991; Nahrgang & Petersen, 1986). Journaling has also aided in the reduction of math anxiety (Barrow, 1984; Borasi & Rose, 1989; Nahrgang & Petersen, 1986; Stewart & Chance, 1995).

The purpose of this study is to assist students in acquiring mathematical language by actively engaging them in discourse through journal writing. This will follow cognitive theory that humans actively construct knowledge through interaction with their environment or social surroundings (Vygotsky, 1962). It will expand past research on vocabulary development by examining developmental mathematics students at the college level and compliment the widely shared view that knowledge is not transmitted from one individual to another, but rather actively and socially constructed by the learner (Cobb & Yakel, 1998; Driver, et al 1994; Burton, 1995). According to Lemke (1990) knowledge is a process subsequent to shared discourses between members of a social community. The interplay of personal experience, language and socialization are vital to knowledge construction. Perry (1970) suggests that these elements are also vital to cognitive development.

Perry's scheme of cognitive development provides a structural framework for studying the college student and cognitive structural changes in the way individuals make meaning of their experiences (Baxter-Magolda & Porterfield, 1985; Taylor, 1984). Perry's theory has been addressed in many research documents (Baxter- Magolda, 1987, 1988; Baxter-Magolda & Porterfield, 1985; Champaigne, 1982; Greenes, 1995; Hodes, 1988; Kloss, 1994; Romero, 1990; Scafetta-Johnson, 1999; Taylor, 1984; Tharp &

Lovell. 1995: Thoma. 1993: Van Heck. 1987). Perry's scheme will be used in this study to assess the levels of cognitive development of developmental mathematics students. Although Perry's scheme contains nine positions, this study focuses on three general categories: dualism, multiplistic/relativistic, and commitment. These general categories serve the purpose of this study, which is concerned with how teaching strategies assist developmental students in moving beyond dualism rather than into any one specific stage. Perry's scheme is very applicable to measuring the cognitive development of college students in the developmental classroom for two reasons. First, students who enter developmental courses are typically in the "dualistic" stage, viewing knowledge and authority as absolutes (Champaigne, 1982). Second, students in developmental courses have typically encountered dualistic teaching styles, i.e., they have only been exposed to one type of instruction and often one method of solving problems (Champaigne, 1982). Exposure to only one type of instruction not only limits students' cognitive development, but it also limits the experiences that students have to aid them in the development of meaning. This has importance because the construction of meaning is dependent upon the individual's level of cognitive development (Driver, et al, 1994).

Discourse and other mediated activities that involve language, such as journal writing, can be instrumental in cognitive growth and the development of concepts by promoting students to question their thinking. This cognitive conflict often referred to as metacognition, causes disequilibration, which is important for movement between the stages associated with Perry's scheme of cognitive development. The need to regain equilibrium will facilitate movement between the stages thus encouraging students to develop higher levels of cognition (Driver, Asoko, Leach, Mortimer, and Scott, 1994;

Baxter-Magolda, 1992). Champaigne (1982) agrees that increasing communication in the classroom should encourage intellectual development. Students who engage in discourse, whether through speaking or writing in the developmental classroom should begin to adopt a different perspective of knowledge, which is a requirement of cognitive development. By examining a connection between cognitive development and language, this research will expand the current research, which focuses on similar connections but with respect to achievement. Investigating these connections with developmental or pre-collegiate students, will narrow the gap in research between elementary, secondary, and college level courses that have already been addressed.

Since communication through the use of language is closely associated with cognitive development, it will be used in the process of journal writing to promote potential change in the cognitive development of students. This study will investigate the connection between language, vocabulary, and cognitive development in the developmental mathematics classroom by considering four specific questions.

1. What is the relationship between learning mathematics vocabulary and cognitive development?
2. What is the relationship between learning mathematics vocabulary and achievement?
3. Does learning mathematics vocabulary differentially impact the learning of non-traditional, adult learners compared with traditional college-aged students?
4. What effect does learning mathematics vocabulary through journal writing have on students of male and female genders?

The literature review will present a more thorough analysis of the theories of language and cognitive development. The connections between language and thought, learning, meaning, knowledge and instruction will be addressed. Social and constructivist perspectives will be included to elaborate on the theoretical framework behind the study. Other important issues addressed in this study include cognitive development and developmental students, traditional and nontraditional students, male and female students, culture and discourse in the classroom, and journal writing.

CHAPTER II

Language and Thought, Learning, Meaning, Knowledge, and Instruction

Learning involves the formation of language to connect one fact with another. one experience with another (Bruner. 1983: Dewey. 1938: Dowst. 1980). According to Vygotskian theory. when we are learning. we use mental tools or signs such as words. mnemonic devices and physical structures (like counting with our fingers) to develop concepts. In mathematics. concepts are often mediated by words because of their inability to be seen or experienced directly. The development of a new concept is invariably foreshadowed by the extended use of basic concepts (Austin and Howson. 1979). Due to the building nature of concepts in mathematics. words that are used for basic concepts later become an important part of the mediated activity and underlying definitions necessary for the development of higher level concepts. The use of words to build concepts in mathematics provides the rationale for using vocabulary as a means of developing language and discourse in the developmental mathematics classroom. "How language is used as a means of communication is crucial to mathematics instruction and hence, for how mathematics is learned" (Abele, 1995, p. 127).

Since language is used to generalize and define, it provides a means for organizing our scope of reality. We classify and categorize our experiences through language, which we may classify as having four aspects: reading, writing, speaking and listening. These aspects are essential to education (Richards, 1990). Reading and writing play key roles in organizing our thoughts, constructing meaning and developing knowledge. Since reading and writing are silent modes of interaction with language, they invoke one's thoughts, which influence knowledge development. Writing causes a deliberate structure of meaning as knowledge about certain concepts is formed. Speaking and listening are important components of learning and instruction. Without the interplay of the two, discourse in the classroom would not be possible.

The organizing design of language allows us to condense our thoughts into phrases and words, which, in turn, can be conveyed to others in the social community. Because knowledge is imparted through language, the origin of language can be important to the development of teaching strategies and understanding of student learning. Feminist theory points out that language is andocentric, since historically women were not in the forefront of formal education. "Hence, women must learn to speak a language that does not, in effect, speak of 'their own' language" (Code 1991, p. 58). By this it is meant that women must connect their experiences to language that does not adequately describe their experiences since most language is "man-made".

Meanings are generalizations or concepts, which are composed of and in our thoughts. When a concept has truly been grasped and has meaning for a particular individual. that individual associates the concept with a significant symbol or is able to express the concept through the use of language.

Words are signs for concepts and are essential for expanding concepts into abstract and higher order generalizations. Scientific concepts often have to be discussed in an abstract context. so there is a need to have specific, specialized symbols or words. Scientific concepts are part of a culture's systematically organized body of knowledge (Dixon. 1996).

> Scientific concepts are not simply passed down by the teacher and absorbed by the student. Instead their meaning is explored during instruction in collaboration with the teacher or capable peers (Minick. 1987. as cited in Dixon. p. 45).

Words that are attached to scientific concepts have evolved in the history of the culture. Students. therefore. use language (eg. words. symbols. and numbers) to shape and define their conceptual development.

In the verbal social interaction of instruction. the word is not only the means of communication. but also the focus or the object of communication. Through instruction. the student's attention is directed to the semantic or logical meaning level of words and the relationships among them as the words are explained compared. reflected on and corrected (Dixon. 1996. 45). The correction of definitions and reflection upon new meaning is very important in the mathematics classroom where words take on unique meaning aside from their everyday use.

Cognitive Development and Developmental Students

Recent research has not investigated a connection between language and cognitive development. as opposed to achievement. in the mathematics classroom. This connection is important since the review of literature shows that language has a strong influence on cognitive development. Two theories of cognitive development were explored for this research. Each of the theories was slanted toward one specific gender. The theory examined that favored the female gender was "women's ways of knowing" (Belenky, Clinchy, Goldberger, and Tarule, 1986). The theory examined that favored the male gender was Perry's scheme of cognitive development (Perry, 1970).

Belenky, Clinchy, Goldberger, and Tarule (1986) interviewed several women in various institutions to gain insights into their knowledge development. They identified common characteristics, which were used to classify ways of knowing for women with five positions: silent knowledge, received knowledge, subjective knowledge, procedural knowledge, and constructed knowledge. The first position of silent knowledge is characterized by an absence of voice. Women in silence deny the realization of self and are solely dependent on external authority for direction. These women are unaware of the potential of their inherited gifts of intelligence and their natural senses. The metaphor of "deaf and dumb" depicts the image of the women in this position. The description as deaf amplifies the inability of these women to learn from the words of others. Dumb illustrates their lack of articulation or voicelessness. Although women in this stage apparently do not learn through listening, they are very capable of expanding their knowledge when they are "shown" concepts by others. Through time, the silent woman develops language, but they do not cultivate their capacities for representational thought. "They do not explore the power that words have for either expressing or developing thought" (Belenkey, et al., 1986, p. 25). Their inability to find meaning in the words of others leaves them passive, reactive and dependent on authorities, which facilitates a view of authority as all-powerful.

The second position is received knowledge. In this position, women listen to others for direction as well as information. Women who rely on received knowledge see language as central to the knowing process. Women in this stage think of authorities as a source of truth. They equate receiving, retaining and returning the words of authority with learning. This stage is characterized by the feeling that facts and ideas cannot be generalized through reflection of one's own experiences, but rather through listening to authorities. Received knowers believe that only one right answer exists and that all other answers, contrary to that view, are wrong. Women in this stage do not follow their own voice, but rather the voice of authority. Although this process is not very personalized, though this process of knowing, received knowers emerge to a powerful sense of their own capacities for knowing.

A third perspective of knowing for women is that of subjectivity. Women who have risen to a subjective perspective of knowing have a conception of truth as personal, private and intuitive. Truth now resides within the persons as formed by their own experiences rather than taught by authority. It is an intuitive reaction not thought out, but rather felt. Because truth for the subjective knower is likened to feelings, strong feelings towards an idea can negate then need to adopt the prevalent view in society. Unlike the received knower for who there is an absolute truth applying to everyone, the subjective knower knows truth that is absolute specific to only one individual. Experience is a valuable source of knowledge for the subjectivist. Women in this position, although not yet independent thinkers, are ready to rely on their experiences rather than authorities in making decisions for themselves. Subjective knowers redefine the nature of authority. They realize that the view of authorities may not match their experience. Therefore, they adopt a cafeteria approach to knowledge and try a bit of everything until something feels right and fits their experience.

A fourth perspective of knowledge for women is that of the procedural knower. This perspective often arises out of a conflict between the absolutist dictates of authorities and the women's own subjectivism (Belenky, et al., 1986). Women in this position struggle with the sounds of their inner voice and the mandates of the experts who "know". Through this struggle, a new presence of authorities as benign eventually emerges which may be critical to the development of the voice of reason.

A reasoned reflection is key in the development of knowledge in the procedural position. It provokes analysis that is conscious, deliberate and systematic. But this analysis follows two independent streams, which splits the procedural knowledge into two categories: separate and connected. Separate knowers require formal instruction to assist them in the struggle during development. Separate knowers analyze by playing the "doubting game" (Elbow, 1973). They assume everyone, including themselves, may be wrong and form arguments to support a decision in many directions. Separate knowers argue that intuition may deceive and gut feelings are not infallible. Therefore, these intuitions should be regarded with doubt. Separate knowers make meaning by using processes that are impersonal and by excluding personal beliefs. For this reason, separate knowers are similar to objectivists. An objectivist would exclude a personal concern and adopt the perspective that the adversaries may respect. Although this may seem to negate the move toward thinking for oneself, by adopting the perspective of an adversary or authority, a more collegial relationship is formed between the separate knower and authority. Through this relationship, the heirachy of the knowledge of authority as above the knowledge of the individual is absolved.

Connected knowers rely on an aspect of care along with the presence of knowledgeable people to form their meanings. They develop relationships with knowledgeable people or material that are centered on caring and nurturing. By showing an aspect of caring, the connected knower can gain access to and is able to analyze other people's knowledge, which in turn builds their own knowledge. Understanding how other people form their ideas or opinions and actively empathizing with the experience of others is an important process in the making of meaning for the connected knower. They have a need to build equality between self and the object of definition in order to create meaning and full understanding. Elbow (1973) claims that connected knowers play a "believing game". Unlike the separate knower who doubts, the connected knower first believes the authority and then forms arguments to stand behind those convictions. For the connected knower, beliefs are founded upon genuine notions of caring and a promise to reveal a truth. The element of caring is a strong characteristic of connected knowledge. Caring for the connected knower like disassociation for the separate knower move the orientation away from self and towards the object that is sought for analyzing or understanding.

A fifth epistemological position is constructed knowledge. Women with this perspective tend to listen with "a voice of integration", finding a balance for reason, intuition, and experience of others. Constructed knowers are articulate and reflective people. They are self-questioning, self-critical, and self-conscious, aware of their own thought, their judgments, their moods, and their desires. Knowledge development at this stage becomes a quest for self. Listening to the voice of reason plays a significant role in the transformation to more complex positions of knowing. This voice is a representation of the self, which is an important instrument of understanding knowledge for the constructed knower. One aspect arising from this position, which is meaningful to education, is the realization of the knower that answers to questions very greatly depending on the context.

Silent women are not aware of their intellectual potential. Women in the position of received knowledge or procedural knowledge let other voices and external truths prevail. At the position of subjective knower, the growth of self and ongoing search for authentic truth is primary. Finally for the constructive knower, reclaiming the self results out of the integration of intuition and the knowledge of others. In all these positions, a search for truth, self-definition and understanding are all present. These positions although defined specifically for women, share common characteristics with the stages of cognitive development as defined by Perry.

Perry's scheme of cognitive development provides a structural framework for understanding the cognitive structural changes in the way individuals, specifically males, make meaning of their experiences (Baxter-Magolda & Porterfield, 1985; Taylor, 1984). Perry developed a criterion for rating a series of transformations in cognitive development that occurs during the college years. Perry's longitudinal study (1970), which used structured interviews with undergraduate students at Harvard, attempted to gain insight into the progression of their cognitive development. Perry identified nine positions of cognitive and ethical development that can be separated into three general categories: Dualism. Multiplistic/Relativistic, and Commitment. Champaigne (1982) drives the focus of this research on only these three categories by the statement,

> "The practicality and significance of the Perry scheme for the developmental educator lies not so much in the exact position of development exhibited by the particular student, but in which of the three general perspectives of duality, multiplicity, or commitment in relativism the student is experiencing."

In the dualism stage (positions 1 and 2), students view knowledge and authority as absolutes that are dualistic: right/wrong, good/bad, and absolute/relative. They believe knowledge is acquired only through an expert or teacher and view that teacher or expert as the authority. The received knowledge stage for women is similar to Perry's cognitive development stage of dualism. As students progress to the multiplistic/relativistic stage (positions 3 – 6), they begin to recognize diversity of opinions depending on the context. They realize that authority figures may not have all the right answers and go to alternative sites such as the textbook, peers, or even the Internet for clarification. Students in this stage realize there can be many forms of the correct answer and many processes to use to work the same problem. They realize that the context of the problem often dictates the process used. Perry's stage of multiplistic/relativistic cognitive development is similar to subjectivism in that they both place emphasis on personal truth which is no longer conceived as absolute and singular, but multiple and infinite. In the last category, commitment (positions 7 – 9), students are prepared to make choices on their own and act accordingly. They also take charge of and guide their own learning.

Piaget's concept of equilibration is important for the movement between cognitive stages. Movement from stage to stage is sparked by cognitive dissonance caused by influences from the environment or community. This creates a conflict between the individual and his/her past experiences and causes disequilibrium. The need to adjust one's way of making meaning to accommodate new experiences and regain equilibrium may result in a movement between stages (Baxter-Magolda, 1988; Greenes, 1995). Movement is a process of overcoming obstacles; a need to find equilibrium. But, equilibrium in each stage is temporary, as exposure to new circumstances will cause a new wave of disequilibrium. Thus, one can understand how social relations play an integral part in the development of the individual (Fleener & Rodgers, 1999).

The stages associated with cognitive development are not hierarchical, but rather follow more of a helix model. Perry explained cognitive growth as a helix with an expanding radius. A helix was chosen because during life the same issues are addressed repeatedly, but the context of each situation has changed. Perry's scheme of cognitive development is practical for studying the college student. It has been addressed in many research documents (Baxter- Magolda, 1987, 1988; Baxter-Magolda & Porterfield, 1985; Champaigne, 1982; Greenes, 1995; Hodes, 1988; Kloss, 1994; Romero, 1990; Scafetta-Johnson, 1999; Taylor, 1984; Tharp & Lovell, 1995; Thoma, 1993; Van Heck, 1987).

Perry's schemes of cognitive development will be used in this research to explore the relationships between cognitive development, vocabulary development, and achievement. Perry's scheme is very applicable to measuring the cognitive development of college students in the developmental classroom. Students who enter developmental courses are typically in the "dualistic" stage or have typically encountered teaching in dualistic forms. Dualistic perceptions towards authority and knowledge as well as exposure to only one type of instruction not only limits students' cognitive development, but it also limits the experiences that students have to aid them in the development of meaning. This has importance because the construction of meaning is dependent upon the individual's level of cognitive development (Driver, et al, 1994).

Although Belenky and others (1986) criticize Perry's scheme for addressing only cognitive development for the male gender, common characteristics have been pointed out between Perry's scheme and "women's ways of knowing". Perry's stages echo some of the same views toward authority and emphasize the search for self that is addressed in Belenky's positions. To explore female development in relationship to Perry's positions, Clinchy and Zimmerman (1975, 1982) developed a semistructured interview using statements representative of those in Perry's study. Their study revealed that women exhibit a progression in cognitive development similar to Perry's model with one exception. In the multiplistic/relativistic stage, women place more emphasis on the inability to know in an absolute sense rather than on a security that knowledge will be resolved in the future. The decision to use Perry's scheme as the method to identify stages of cognitive development in this study was influenced by Clinchy and Zimmerman's study and the fact that the Scale of Intellectual Development (SID) was developed with Perry's perspective as opposed to a feminist perspective.

Knowing how students are constructing meaning is important to the implementation of appropriate methods of instruction. Students' construction of meaning is impacted by their level of cognitive development and by their knowledge capacity. The zone of proximal development (ZPD), defined by Vygotsky (1962), is that space that exists between a student's current knowledge and the potential for further development of that knowledge. Vygotsky states that, for individual progress, it is important for instruction to include various opportunities for knowledge development within the ZPD in order to bridge the gap from current knowledge to expanded knowledge.

One purpose of developmental courses is to move students to positions of higher cognitive development. Vygotsky believes that this is accomplished most readily in the ZPD. Champaigne (1982) states that increasing communication in the classroom should encourage intellectual development. Students who engage in discourse, whether through speaking or writing in the developmental classroom should begin to adopt a different perspective of knowledge, which is a requirement of intellectual development. Their discourse is an instrument that provides insight into their present knowledge or understanding and potential knowledge.

A focus of education at all levels should be to facilitate a student's transition from lower to higher stages of cognitive development (Champaigne, 1982; Nelson and Smith, 1989; Thoma, 1993). To facilitate the movement from one level to another, teachers need to upset the equilibrium of dualism by making students aware of the uncertain nature of knowledge (Driver, et al, 1994; Thoma, 1993; Piaget, 1972). In the mathematics classroom, this means developing a student's awareness to various procedures for solving problems based on the perspective from which they view the problem and to various forms of the answers to each problem. It can also include the instruction on words that take on new meaning in the mathematics classroom that differ from everyday use.

Learning is a process of self-organization: of reorganizing existing experiences to regain equilibrium. As a result of the resolution of disequilibrium, a student moves in his/her level of cognitive development and learning takes place (Driver, et al, 1994).

"Progression (through intellectual stages) is accomplished through the interactions of the learner with their environment including physical and symbolic representations" (Perry, et al, 1986). These interactions lead the individuals to restructure the way in which they perceive the world and their knowing. Therefore, it is important to focus on a social and psychological prospective while trying to impact the cognitive development of students.

Social and Constructivists Perspectives

Several theorists who embrace social and constructivist theories have studied language in detail. The theories of Vygotsky (social constructivist theory), Mead (social behaviorist theory), Code (feminist theory), and Brunner (cognitive and culture theory) will be expanded upon in this section. There are commonalities among their theories as well as differences, which relate to the topic of the role of language in concept development. An outline of those characteristics will be given below as they relate to this research on cognitive development in the mathematics classroom.

Vygotsky (1962) perceives language as a social construct because it is learned through social interactions, which are deemed necessary in the development of language and thought. Vygotsky states that cognitive development is the result of social interactions within our environment and that behavior must exist socially before it can become part of the internal behavior of an individual. When an individual attaches meaning to a behavior that exists socially, it can be used to organize ideas internally. This concept of internalization is key to Vygotsky's theory of cognitive development. As we attach meaning to expressions used in a community, the expressions become part of our shared language. This language is then internalized and used to extend and facilitate our cognitive development. The ability to formulate ideas with language enables us to branch our knowledge to more complex, abstract, and scientific notions.

Although the primary function of language is communication, the culturally established meanings communicated during school instructions require language for the more abstract and systematized scientific concepts (Dixon, 1996). In order to think about scientific concepts that have an abstract nature to their content, words and their meanings are necessary to guide a student through the development of concepts. Vygotsky (1962) argues that scientific concepts are developed and constructed through the use of signs or words associated with them during social and verbal interaction with others. Vygotsky does not believe that students learn the meaning of the words as they are used, but rather *through their use, the meaning takes shape and is internalized.* To shape meaning, words must be used in a specific context, which most readily happens in a social structure such as the classroom. Initially students may not have full understanding of a word's meaning; but through activities that illustrate and expand upon the concept signified by a word, the student begins to negotiate the meaning of the word for himself/herself and as part of the community for which the word has relevance.

Mead (1934) suggests language is a fundamental tool for communication in the social community. Mead agrees with Vygotsky that at a very young age children assign signs, including words, to ideas and gestures that comprise our experiences. Mead believes that language is constituted by behaviors, those phases or acts that are used to communicate with others and bring about responses from others. Gestures must have meaning in the experience of the sender and illicit similar meaning in the receiver. Individuals may not have identical meanings initially, but through co-operative activities and individual adjustments, meanings are negotiated. When a behavior is understood through the negotiation of meaning between the sender and receiver, it becomes a significant symbol. A significant symbol can be common to all, but the varying experiences of an individual causes the meaning of the significant symbol to be slightly different for each person. Thus, Mead argues that experience and behavior play an extensive role in the development of these symbols and their meaning. In fact, Langer (as sited in Berthoff, p. 101) believes that this experience is a fundamental motivation of language.

The relationships among symbol, gesture, communication and concept are complex. In a given social group, every gesture represents a particular act or response, namely the response it calls for implicitly in the sender and explicitly in the receiver. Thus through the negotiation of a behavior, its meaning evolves and it emerges as a significant symbol for that community. Through the use of these significant symbols communication becomes possible. Often to facilitate the communication, a vocal gesture or word is attached to a significant symbol or becomes a significant symbol. Through the use of these vocal gestures, a language evolves that is used for communication. This communication through language enables a person to express ideas and thoughts to others and exhibit intelligence. It is out of language that the "field of mind" emerges (Mead, 1934, p.133). The field of mind describes one's ability to reflect on thoughts and to develop meaning and understanding using an "inner" voice of reason.

Both Vygotsky and Mead emphasize the relationships among symbols, gestures, communication and concept development. Both also emphasize the importance of shared meanings for communities. They differ however in the role of the more knowledgeable other. the nature of mind. and the potential for shared meaning. Neither addresses power relations and social structures that influence communication. However. feminist theories of language development. especially with origins in post Marxist dialectic. contribute power relations to the discourse about language. knowledge. and self.

Code (1991) agrees with both Mead and Vygotsky that language is specific to a social community. "They [languages] show what objects. events. and experiences a linguistic community considers worth naming and how that community constructs the relations of objects and event to one another" (Code. 1991. p. 58). The language of the community reflects the structures of reality for its members and thus impacts the way in which experiences are translated to knowledge. Language is a strong medium through which experiences become the basis for knowledge. The feminists focus however. challenges that because most language is andocentric. it hinders the translation of experiences to knowledge for women. This may be the case with much technical language. including mathematics. as a logic of domination supports traditional malestream ways of knowing over more traditionally female ways of knowing (Fleener. 1999). Specific social context plays a fundamental role in knowledge development. For this reason and the need to understand technical language. instruction should be revised to encourage students of the female gender to develop meanings that incorporate their own personal experiences. Code feels that emotions such as curiosity. interest. and amazement are necessary to the construction of knowledge. It is for mere emotions that many inquiries have been undertaken and researched. Emotion and intellect are mutually essential and supporting rather than oppositional forces in the construction of knowledge (Code. 1991). The characteristics and positions of knowing for women as defined by

Belenkey are observed by Code as important to the understanding of cognitive development for women.

Bruner (1983) agrees with Vygotsky that language is acquired not in the role of a spectator, but through its use and active participation. Language is used to make sense of experiences either by talking about them or by meditating on them. Language is critical for participation in social structures that serve as the catalyst to the development of new language specific to that social structure. "Language is a highly organized, systematic means of representing experience, and as such it assists us to organize all other ways of representing" (Britten, 1971, p. 21). Bruner would agree that language is important to cognitive development since people use language and reason as one way of understanding their world.

Britten (1971) and Bruner (1983) consider language and thought as separate ideas because their origins and development are different. They agree that although these ideas are separate from one another, language and thought are in constant interaction with one another. Bruner argues that language impacts cognitive development, but thought, on the other hand, is the outcome of cognitive development. Bruner believes that effective instruction can facilitate and even accelerate cognitive development, since social and cultural factors play a significant role in cognitive development. Brunner (1983) claims that the result of education should be that the learner is an autonomous and self-propelled thinker. Bruner, like Vygotsky, believes that individual development is best understood within the context of the social and cultural setting in which it is embedded.

All of these theorists have a shared interest in the idea that language is socially constructed. Social constructivism emphasizes the interaction among individuals, society and knowledge out of which meaning, including mathematical meaning, is created (Burton, 1995; Driver, et al, 1994). Through the socialization process, students are introduced to the concepts, symbols, and conventions of a scientific community. Social interactions in the classroom become the catalyst to the negotiation of the meanings of scientific ideas. During these interactions, the learner as opposed to knowledge becomes the focus. In making mathematical learning a personal experience, we change the focus from knowing *that* a particular mathematical outcome exists to knowing *why* the outcome is likely within the context we are studying. This causes knowledge to be subjective as opposed to objective and empirical (Burton, 1995).

Other researchers have also endorsed the philosophy that language and knowledge are connected. It is a widely shared view that knowledge is not transmitted from one individual to another, but rather actively constructed by the learner (Cobb & Yakel, 1998; Driver, et al, 1994; Burton, 1995). Lemke (1990) views knowledge as a process subsequent to shared discourses between members of a social community. The interplay of personal experience, language and socialization are vital to knowledge construction.

Burton (1995) endorses this in his proposition of five categories for aiding students in constructing mathematical knowing. They are:

- person and cultural/social relatedness
- aesthetics of mathematical thinking
- nurturing of intuition and insight
- recognition and celebration of different approaches particularly in styles of thinking
- globality of its application

Using these categories, dualisms such as the right/wrong dichotomies would be displaced and a multiplistic approach to thinking would be promoted. These categories also make knowing mathematics a function of *who* is claiming to know rather than *how* the knowing is presented. Journal writing is a method often used during instruction that addresses these categories through the call for reaction to entries about feelings, intuitions, insights, and personal explanation or meaning.

Britten (1971), like Vygotsky and Mead, states that we create representations of our experiences in order to use them to make sense of our next encounters. These representations are symbols. A key way of representing with symbols is through the use of language. The ability to speak and to reason is highly dependent upon our ability to generate and use symbols, our representations of our experiences. Language is an important system of symbols with which to represent our experiences because it can be easily brought "up-to-date" as our experiences are modified and extended. "Language is a highly organized, systematic means of representing experience, and as such it assists us to organize all other ways of representing" (Britton, 1971, p. 21). We use language to classify our experiences. However, social communities from which our language is adopted affect the way in which they are classified. When we classify experiences with words, we are creating categories that are congruent with those used in the social communities to which we belong. The theories cited above support the argument that language is important for learning, meaning making, constructing knowledge, and teaching. Since the mathematics classroom is composed of students of different ages and different genders, language and discourse will be inherent in the construction of a positive learning environment for diverse students.

Traditional and Nontraditional Students and Gender Differences

Extensive research exists which focuses on gender and the learning of mathematics. Several researchers have found a significant decline in positive attitudes toward mathematics for students of the female gender as they progress through secondary school (Brush, 1985; Eccles, Adler, Futterman, Goff, Kaezala, Meere, & Madgly, 1985; Eccles & Blumenfeld, 1985; Fennema & Sherman, 1977; Hyde, Fennema, Frost, & Hopp, 1990; Reyes, 1984; Stodolsky 1985). Women are more likely to experience math anxiety (Betz, 1978; Hyde, et. al., 1990; Hunt, 1985), which affects these negative attitudes. Expectations for success and lack of self-confidence in their overall ability also affect attitudes of females in mathematics (CME, 1986; Eccles, 1987; Fennema & Sherman, 1977;Gutbezahl, 1995; Leder, 1992; Meyer & Koehler, 1990; Reyes, 1984; Reyes & Padilla, 1985). These negative attitudes are thought to have detrimental impact on women's mathematical achievement (Hyde, et. al, 1990).

Achievement in mathematics has been significantly lower for females when compared to males (Beller &Gafni 1996; Fan, Chen, & Malsumater 1997; Fennema, 1985; Hodges & Nowell 1995; Hyde, et. al, 1990; Sherman & Fennema 1977). Hyde and colleagues (1990) conducted a meta-analysis of 100 studies to investigate a significant difference in women's mathematics performance, relative to their male counterparts. They found that a mean effect size is significant but small, d = .20. Their research suggests that a decrease in achievement is apparent for women starting in high school and continuing though college and adulthood. Some researchers have found lower achievement in mathematics for females, in comparison to males, when they studied the results of standardized achievement tests (Benbow & Stanley, 1982; Han, 1993; Harrington & Harrington, 1995; Hyde, et al., 1990; Sharp, 1989). Others reseachers examined course grades and enrollment in higher level math courses to document this same significant difference (Bridgman & Wendler, 1991; Chipman & Wilson, 1985; Maple & Stage, 1991; Reyes, 1984). Murphy (1992) claims that the lack of enrollment by females in higher-level mathematics courses perpetuates the differences between genders.

Some studies, however, claim that the gender gap seems to be narrowing with respect to both attitudes and achievement (Brophy, 1985; Friedman, 1989; Hyde, Fennema, & Lamon, 1990; Hayes & Slate, 1993; Marsh, 1989; McLeod, 1992; Meece, Wigfield, & Eccles, 1990). Campell (1993) gave evidence that most of the gender gaps were disappearing from their peaks of the 1950s. A few studies have examined course grades and found no significant differences between genders in recent years (Kianian, 1996; Warner & Steinberg, 1992).

The differences measured between genders may be attributed to the fact that mathematics is believed to be a male domain (Eccles, Jacobs, & Harold; 1990; Fennema & Sherman, 1977; Gutbezahl, 1995; Hyde & Jaffee, 1998; Koehler, 1990; Leader, 1986; Tarte & Fennema 1995; Sax 1994). Some research results indicate that teachers make major contributions to the development of gender differences (CME, 1986; Fennema, 1981, 1996; Hyde & Jaffee, 1998; Koehler, 1990; Reyes & Padilla, 1985). Teachers often exhibit greater expectations for male students than female students (CME, 1986). Fennema (1981) suggests that teachers expect males to be better at problem solving than females; therefore, they encourage males to engage in more problem-solving activities.

Reyes and Pacilla (1985) claim that the teacher has the most influence on the students' mathematical learning in the school setting.

Social and cultural factors have also contributed to the gender gap in mathematics (Badger, 1981;Eccles & Jacobs, 1986; Fennema, 1985; Fox, Tobin, & Brody, 1979; Leder, 1990; Meece, Parsons, Kaczalla, Goff, & Futterman, 1982). Badger (1981) concludes social factors rather than genetic factors have caused the relative poor performance of girls in mathematics. Fennema (1985) argues that social conditions and personal beliefs of females account for gender differences. Leder (1990) suggests that environmental factors directly influence students' beliefs about the self and attitude towards mathematics. These environmental influences which are linked to gender differences include: schools' and teachers' differential treatment of male and female students, parents' differential expectation of their sons and daughters, peer expectations for appropriate future carriers of women, and learners' internal beliefs and conformance to cultural values. Fennema (1990) suggests that modifying the environmental factors that influence existing gender differences in mathematics participation and achievement can provide justice and equity in mathematics education. Since language is a social construct, defined by the constituents of the community of which it belongs, language can be an environmental factor influencing gender differences. The current study will investigate any differences in genders that may be present after a journalizing process is implemented to promote language development, thus effecting achievement.

Research on nontraditional students and learning mathematics is not as prevalent as research on gender differences, despite the fact that, in 1990, a nationwide survey of all types of institutions indicated that 6 million nontraditional students were studying for college credit each year (National Center for Educational Statistics, 1992). These nontraditional students represented 45 percent of all undergraduate and graduate students. The lack of research on nontraditional students might be a result of the fact that this population has been grouped with adult learners in past research. It is an extreme generalization to group everyone over the age of 25 as an adult learner (Osgood-Treston, 2001), since education for the adult learner has historically been defined as "a separate, peripheral activity, and its clientele is completely outside the compulsory-attendance age groups" (Clark, 1980, p. 58). Wlodkowski (1999) acknowledges that despite the fact that a separate comprehensive theory of adult learning does not exist for nontraditional students, there does exist the unifying assumption of adult learners and nontraditional students as highly pragmatic and responsible.

Literature on adult learners characterizes these students as independent, practical, and oriented toward experiential modes of learning (Brookfield, 1988; Cross, 1981; Darkenwald & Merriam, 1982; Knowles, 1980, Long & Ulmer, 1989). Mortimer and Simmons (1978) describe adults as initiators of their own socialization (learning) experience and as autonomous in relation to socializing agents such as teachers. These adult characteristics are also used to describe nontraditional students by several researchers (Ahar & Skenes, 1993; Bamber & Tett, 2000; Dill & Henley, 1998). Dill and Henley (1998) define adult learners or nontraditional students as those filling multiple roles such as parenting, working and attending college. The drive for independence, practical assessment of current skills, and responsibility for one's own education motivates the returning adult to participate in remedial level courses to renew basic language and computation skills (Miglietti & Strange, 1998).

The nation's community colleges service most of the nontraditional students (National Center for Educational Statistics, 1992); therefore, a wealth of research focuses on students at those institutions (Baker, 1998; Boss, 1985; Cohen & Brawer, 1996; Governanti & Clowes, 1982; Mickler & Zippert, 1987; Miglietti & Strange, 1998; Shively, 1989; Smith & Vellani, 1999; Winter & Harris, 1999;Luzzo, 1993). Several researchers have investigated the construction and effects of a positive learning environment for adult students. They conclude that the environment can be affected by following prescriptive practices such as responding to the purposes and needs of the learners (Apps, 1991; Hu 1985; Hughes, 1983; Knowles, 1980; Lawler, 1991; Meadors, 1984; Seaman & Fellenz, 1989), recognizing the diversity of the learners (Barer-Stein & Draper, 1993; Fisher & Sartorelli, 1992; Galbraith, 1991; Knowles, 1980; Lenz, 1982; Nelson, 1996; Seaman & Fellenz, 1989), and encouraging active learning (Brookfield, 1986; Borzak & Hursh, 1979;Galbraith, 1991; Knowles, 1980; Silberman, 1996).

Nontraditional students have purposes and needs that differ from those of traditional students. Adults come to education voluntarily. Aslanian and Brickell (1980) suggest that the majority of adults participate in learning due to some life-altering event: divorce, job change, death in the family, relocation, retirement, etc. Adults view education as a way of coping with the transitions in their life. This is different from traditional students who attend college as an extension of their schooling, fulfilling expectations of society (Lawler, 1991). Darkenwald and Merriam (1982) found that nontraditional students enroll in college courses to satisfy personal, social, religious, or cultural needs, to meet new people or to change their routine. In order to satisfy personal needs, the nontraditional student generally enrolls in college courses in order to obtain career advancement, to facilitate a career change, or to keep up with new knowledge (Hu, 1985; Meadors, 1984; Seaman & Fellenz, 1989). Many times nontraditional students simply need to obtain college credit hours as a means of satisfying high school diploma equivalencies (Seaman & Fellenz, 1989; Darkenwald & Merriam, 1982). The National Center for Educational Statistics (1992) found that males are more likely to return to courses to enhance careers (21 vs. 17 percent), while females are more likely to return for personal reasons (11 vs. 8 percent).

Seaman and Fellenz (1989) list several needs that should be met for nontraditional students.

- Adult learners must perceive their knowledge acquired through courses to be helpful in attaining their desired goals.
- Adult learners need to be exposed to various teaching strategies to meet their diverse experiences.
- Adult learners need to realize a "pay off" for their learning efforts in the near future to remain interested.
- Adult learners have special needs due to jobs, families, and community responsibilities. They need some flexibility in scheduling and assignments to accommodate all these commitments simultaneously.

"As long as the learning one seeks is perceived as movement towards meeting one of these selected needs, the learning will be continued (Seaman & Fellenz, 1989, p.9)."

The diversity of nontraditional students as opposed to traditional students in the college classroom has also drawn attention from researchers (Apps, 1991; Barer-Stein & Draper, 1993; Fisher & Sartorelli, 1992; Galbraith, 1991; Knowles, 1980; Lenz, 1982; Nelson, 1996; Seaman & Fellenz, 1989). A large contributor to this diversity is the accumulation of experiences, background, competencies and responsibilities of the learners (Apps. 1991: Bean & Metzer. 1985: Hostler. 1997). Metzer (1986) found that older students are more likely than younger students to be female and married. Older students also report more dependents and are often first-generation college students. The socioeconomic status of older students has more variance than and is often significantly lower than that of younger students (Kuh & Ardaiolo. 1979: Bean & Metzner. 1985). Apps (1991) suggests that past experiences of nontraditional students influence perceptions and assimilation of new material: how it is organized. what is important. what is self-relevant. and what is really "new". Adult students value the knowledge that has been gained from past experience and want this experience integrated into current education and learning (Meadors. 1984). One way of meeting these diverse needs is to expose the students to various teaching strategies (Seaman & Fellenz. 1989: Silberman. 1996).

Active learning. also called experimental learning. is the process of involving students in learning through reading. writing. discussing. or engaging in higher-order tasks such as analysis. synthesis and evaluation (Bonwell & Eison. 1991). Silberman (1996) describes several teaching strategies to promote active learning. Some of these strategies include: group work. reflective writing. real world applications. short quizzes. periodic pauses during lecture. demonstrations. internet exploration. problem solving. and computer based instruction. Borzak and Hursh (1979) suggest that active learning promotes change in students' cognitive development and self-perceptions. This is due to the decentering and reciprocity effect of active learning. Decentering is the process of incorporating multiple perspectives or approaches in dealing with problems. while reciprocity is the ability to achieve mutually satisfying understanding with others in the social setting. Since nontraditional students are characterized as being more reflective learners (Cross, 1981), this research incorporated journal writing as a teaching strategy to promote active learning. The journals will also promote a positive culture in the classroom by accessing academic needs of both traditional and nontraditional students, renewing the basic language of mathematics, and facilitating active learning through classroom discourse.

Culture and Discourse in the Mathematics Classroom

The culture of the mathematics classroom is vital to student learning. Wertsch and Bivens (1992) believe we are empowered as well as constrained in specific ways by the mediational means of the sociocultural setting that the classroom offers. In this study we are concerned with the impact of two specific aspects of that culture. They are language and discourse. In the social community of a classroom, four aspects of language are the media used to facilitate discourse among all the members and to communicate ideas and concepts. These aspects are reading, writing, speaking and listening. Vocabulary is key to all these aspects of language and thereby is an important component of this study. The vocabulary used in mathematical learning provides the symbols for concepts whose meanings must be negotiated though discourse and discussion. To mediate this meaning, discourse is needed and takes shape though reading, writing, speaking, and listening. Speaking and listening are activities that support one another, just as teaching and learning are actions that loose their significance without a union.

Teaching and learning should not be viewed as two separate activities that are causally linked, but rather as the result of sharing and negotiating beliefs, goals and intentions. The interaction between teaching and learning forms a culture within the classroom (Cobb & Yakel, 1998; Olson & Bruner, 1998). In the mathematics classroom, the culture is created by the members and influenced by the individuals' constructions of knowledge within the classroom (Cobb & Yakel, 1998). The culture is also influenced by teacher's views about the students, which become reflected in the beliefs and assumptions about teaching and directly impact the learning process. In order to understand each individual's construction of knowledge and to develop the teacher's views about the students, journal writing was used in this study as an instrument to disclose changes in development and depth of understanding while facilitating discourse during this study.

Leaning is not a one-sided process. The teacher and the learner must share in the responsibilities of the outcome (Rogoff, Matuson, & White, 1998). Learning is not simply the acquisition of knowledge; but rather, it is a transformative process in sociocultural activities where new information is reconciled with existing structures (Fleener & Rodgers, 1999). Therefore, the relationship between the learner and the culture of the classroom needs to be dialectic. As a result of the interaction between the learning and the culture, the two are both transformed and changed. The reaction between the learning and the culture is seen in the discourse; the sociocultural and cognitive process that produces a joint interaction between thinking and talking (McNair, 1998).

From a Vygotskian perspective, the culture of the mathematics classroom is key in the development of signs and symbols that are used to organize thinking. The classroom culture is responsible for the social interactions that are required to raise a student to the zone of proximal development (ZPD) (Cobb & Yakel, 1998). The instructor in this study was able to investigate the level of understanding of students through the reading of their journals. This enabled the instructor to incorporate activities that would engage students in active learning that enhanced the culture of the classroom while promoting learning in the ZPD.

As active participants in the mathematics classroom, students should adopt the perspectives, beliefs, values and expectations consistent with those of the mathematics community and use these during analysis of mathematics problems (McNair, 1998). This emphasizes the importance of the mathematics classroom being a "culture" in which principles and standards are modeled.

Not only does a culture have its own beliefs, values, and intentions, but it also has its own language, discourse and history (McNair, 1998). For this reason, we should address activities in the classroom that will promote discourse and language. The Professional Standards for Teaching Mathematics (National Council of Teachers of Mathematics [NCTM], 1991) argue that "the nature of classroom discourse is a major influence on what students learn about mathematics" (p. 45). Code (1991) agrees that discourse has much power in shaping experiences. It assists in construction of experiences so that the 'owner' can recognize them. To encourage students to become full participants in the classroom and take ownership of their learning, journal writing can be implemented as a method of instruction to generate discourse and propagate language development in the classroom. This classroom activity will also provide an instrument for assessing the level at which students are adopting the beliefs, values and intentions of the mathematics culture and community.

Journal Writing and Mathematics

During the last two decades, mathematics instructors have begun requiring their students to write as an integral part of mathematics instruction. This required writing was a result of the Writing Across the Curriculum (WAC) movement of the '70's and the Writing to Learn movement of the '80's. The WAC promoted writing in all disciplines to improve writing skills whereas the Writing to Learn movement focused on thinking toward a better understanding of the subject matter regardless of the writing skills. Both these movements have had a positive influence on learning (Pugalee, 1997; Waywood, 1994). They have caused a more concerted effort on writing in the classroom, which has shown benefits for students as well as faculty (Borasi & Rose, 1989; Chapman, 1996; Huffman & Powell, 1989; Johnson, 1983; Mayher & Brause, 1983; Mett, 1989; Miller & England, 1989; Nahrgang & Petersen, 1986; Stempien, 1985; Vukovich, 1985). These benefits contributed to the improvement of mathematics instruction and learning. These movements have promoted better communication skills in the mathematics classroom and encouraged instructors to use writing as a tool to empower students to take a more active role in the learning process, while preparing for the use of mathematics beyond the classroom.

Borasi and Rose (1989) conducted a qualitative study to reveal potential benefits of journal writing for mathematics instruction. Their research followed an ethnographic content analysis design. Various documents that reflected social interactions in the classroom were studied and analyzed to identify recurring patterns or themes and to explain the benefits of writing to learn mathematics. Through this analysis, a taxonomy was determined to classify the recurring themes and benefits. The taxonomy included four student benefits from writing the journals and three teacher benefits from reading the journals.

Students benefit in four ways from journal writing. First, there is a therapeutic effect from reflecting on one's feelings about mathematics, which become apparent in writings. Secondly, writing can increase a student's knowledge of mathematics because writing causes a deliberate structure of meaning and allows one to make connections between past and present material. A third benefit is an improvement in learning and problem-solving skills caused by the reflective and generative qualities of writing. Finally, students benefit by reevaluating their view of mathematics and their beliefs about the discipline.

Teachers can benefit as they read the students' journals. Increased individual knowledge of each student can be gained from the journals. This knowledge can be used for remediation and alternative assessments. Teachers can also use the journals to give feedback to the students. This feedback can be used to guide a student's thought in hopes of directing the student to the zone of proximal development. Teachers should also be concerned with raising the class to the zone of proximal development. The journals shed light as to the direction the instruction should take to facilitate learning in the zone. The structure of the course or style of instruction can be modified in response to student feedback to promote learning in the zone. Journal entries can impact methodologies and teaching approaches by providing new insight about students, teaching and learning.

Additional benefits were observed from the dialogue between student and teacher in the journal. This dialogue provided for more individualized teaching and guidance. It also promoted a more caring and non-adversarial classroom atmosphere. Overall, this analysis suggests that journal writing may provide a valuable addition to current modes of mathematics instruction.

Written language can be classified into transactional and expressive writing (Britten, 1975). In transactional writing, the focus is on the final process. Summaries, reports, essays, and note taking are types of transactional writing. Expressive writing is thinking aloud on paper and writing down your immediate thoughts. Expressive writing can be used to record one's present feelings, thoughts about a specific problem, or anxieties. The journal entries used in this study were a combination of both styles of writing (Appendix 1). In the creation of journal questions, four different writing prompts were used: contextual, definition, reflective, and miscellaneous. Contextual prompts ask students how they feel or think about mathematics. Definition prompts focus on the vocabulary specific to each day's lesson and the students' understanding of the word. Reflective prompts are given to promote clarification and deeper understanding of the concepts; these prompts question a student's reasoning. Miscellaneous prompts include a wide variety of questions that are usually answered creatively; these do not have to be specific to mathematics. The strategy for journal writing using these prompts was designed, implemented, and explored by several researchers (DiPillo, Sovchik and Moss, 1997; Dougherty, 1996; Miller, 1990; Miller and England, 1989). Miller (1990) and

Miller and England (1989) worked on a team consisting of three secondary teachers and two university faculty to create the classifications for prompts that would contribute most to the improvement of mathematics instruction. They focused on prompts to develop positive student attitudes, create feedback for instruction and provide insight into student understanding and specific needs. DiPillo, Sovchik and Moss (1997) developed prompts for a fifth and sixth grade mathematics class using the four categories created by Miller and England (1989). Conclusions from their qualitative analysis of student journal writing suggest that journal writing meets the professional standards (NCTM) for teaching mathematics by providing a medium in which teachers can reflect on their teaching, by providing an alternative method for assessment, and by emphasizing the need for conceptual understanding over computation. Dougherty (1996) used prompts to contribute to the mathematics instruction in an eighth grade classroom. The prompts used in this study were grouped in three categories: mathematical content, process, and affective/attitudinal. These categories are similar to those used by the researchers sited above. Doughtery (1996) concluded that journals add a rich element of discourse to the mathematics classroom by providing an additional avenue for student/teacher communication. Cameron (1984) suggests that prompts, as opposed to free-style writing, be used for journal writing in the developmental classroom because students at this level are not usually self-directed learners.

Harchelroad and Rheinheimer (1993) conducted a study to investigate the effects of writing in mathematics. Students, enrolled in a pre-college summer program designed for educationally and economically disadvantaged youths, were assigned randomly to two groups. The treatment group was asked to write in a journal during the last ten minutes of class and make conceptual connections between the current lesson and previous lessons. The control group was asked to do practice exercises during this same time period. The researcher's hypothesis was that the treatment group would outperform the control group at the end of an eight-week summer session. The students were given the Scholastic Aptitude Test (SAT) at the beginning and ending of the study. SAT scores and results from an in-house mathematics placement test confirmed the homogeneity of the groups. Pre- and post-test scores for the two groups were analyzed using an analysis of variance. The results of this analysis showed a significant difference in the scores in favor of the students in the control group. One reason the researchers gave for this opposition to their hypothesis is that the post-test did not include problems specific to conceptualization or pertaining to problem-solving which journal writing would have influenced. Another factor that could have affected the results is a lack of true control. The use of class time for individual work on various exercises could be seen as a different, more effective treatment for this particular study. They suggest that this study be repeated with a different pre/post-test instrument, one designed to more accurately reflect the writing experience. Other variables that should be tracked are gender and traditional students.

Bell and Bell (1985) designed a pilot study to test the claim that expository writing with instruction in mathematics problem solving should produce measurable results that yield an increase in problem-solving abilities. Two ninth-grade general math classes were used. One as the control received only traditional methods of teaching problem solving, and the other (the experimental) received the traditional method as well as a structured expository writing component. Pre-tests were given at the beginning of the study to test competencies with problem solving skills. No significant difference between the groups was found at the beginning of the study ($p = .01$). Four weeks after the study had been completed, post-tests on problem-solving skills revealed that there was an increase in problem-solving skills for the treatment group and the difference between the groups was now significant ($p = .01$). This indicated that the writing component had affected the ability of students in problem solving.

Stewart and Chance (1995) conducted an investigation of the use of journal writing by students and teachers in a first-year high school algebra class. Four classes were used in the study, two as control and two as experimental. The students in the experimental group wrote responses to prompts three times a week for five minutes each. The prompts they were given included mathematics concepts and procedures, curriculum issues, and free writing. Journal responses were analyzed by the level of math understanding, the nature of their content, and recurring themes or common patterns. To study the cognitive and affective changes in the groups, the MARS-A and Tennessee Comprehensive Assessment Program (TCAP) were used. Independent t-tests were performed on pre- and post-test scores. The results indicated a significantly greater increase in achievement for the journal-writing students ($p \leq 0.05$). Pre- and post-anxiety test revealed a decrease in MARS-A ratings, which also approached significance ($p \leq 0.07$).

These articles convinced me to use a quasi-experimental design with a correlational technique to study the impact of language and classroom discourse on cognitive development, achievement and vocabulary development. The Scale of Intellectual Development (SID) (Erwin, 1983), the College Placement Test (CPT)

(The College Board. 1994) and Vocabulary Knowledge Test (Miller & Smith, 1994) were used to investigate several correlations between language, cognitive development, and achievement. The study used a convenient sample of students enrolled in Basic Algebra in the spring of 1999.

CHAPTER III

Methods

A review of the literature was presented in the previous chapter to provide the theory and support the use of Perry's model to assess cognitive development levels of developmental mathematics students. These theories and the literature review substantiated the claim that language is closely associated with cognitive development. Due to this connection, language development through journal writing was used as a tool to initiate potential change in the cognitive development of students. The guiding question addressed by this research is: How does focusing on language and classroom discourse impact the cognitive development, achievement, and vocabulary development of developmental mathematics students?

This quasi-experimental study was conducted to investigate the impact of language development on cognitive development in the mathematics classroom. A two-group design with control and experimental groups wad used. The experimental treatment was journal writing, which focused on vocabulary, language, and concept development. Pre- and post-tests were administered to both groups to explore significant differences with regard to cognitive development, achievement and vocabulary development between groups.

Sampling

College students who enrolled in the developmental mathematics course, basic algebra, were studied. A convenience sample of two classes that were taught at 9:00 and 11:00 a.m. was used. Although, all students participated, the final sample included eighteen students: seven from the 9:00 class and eleven from the 11:00 class. The class was offered in the spring of 2000 at a university located in the southwestern region of Oklahoma. The pseudonym of Heartland University will be used to refer to the institution. Heartland University is one of eight regional institutions in this southern plains state and has a current enrollment of approximately 5000 students. This university was chosen out of convenience. Students attending the university tend to be from rural areas and come from a population that is not mobile. Therefore, they are generally homogeneous. Basic algebra is a mathematics course used only to remove mathematics deficiencies and is not included in any plan of study on campus. This course was chosen for the study because developmental mathematics courses are designed to facilitate a change in cognitive development and eliminate differences in content knowledge and preparation for college mathematics.

The researcher taught both classes to control variation in instruction. The basic algebra course met daily for one hour, during a 16-week semester. One class was scheduled for 9:00 a.m. and the other for 11:00 a.m. Both courses used the same textbook. Elementary Algebra: Concepts and Applications, 5th edition, and were given the same assignments and tests throughout the semester. A coin was tossed and it was decided to use the 9:00 class as the control group and the 11:00 class as the experimental group.

Measures

The three measures used in this study were the College Placement Test (CPT), Scale of Intellectual Development (SID-IV), and a researcher designed vocabulary test. The College Board created the CPT to place college students in appropriate mathematics classes based on their abilities. Three sections of the CPT are used to place students in developmental courses: arithmetic, elementary algebra, and college-level mathematics. The composite test value from these three sections is used to match students' abilities with the class in which they are most likely to succeed. The composite score from the CPT was used for this research because it is the only score kept on file for the students at Heartland University and it is used as a reliable predictor of student mathematics achievement. The College Board conducted research on the validity and reliability of the test. Two hundred participants were used from colleges and universities around the country. The reliability coefficients for each test were .91, .91 and .87 for arithmetic, elementary algebra, and college-level mathematics respectively. The validity of the CPT is predictive of student success in developmental mathematics courses.

Erwin's (1983) Scale of Intellectual Development (SID) was developed based on Perry's scheme of intellectual and ethical development and Robert's Scales of Ethical and Intellectual Development (SEID). The SID is an experimental instrument used to measure cognitive development. The questionnaire consists of statements to measure the extent to which students are intellectually developing during their college years. It consists of 101 items that are composed of a four-choice Likert format. The SID was administered to over 3000 freshmen. The resulting factor analysis showed that the statements did not support Perry's nine positions, or stages, in cognitive development but rather only four sub-scales (Dualism, Relativism, Commitment, and Empathy). Dualism measures the extent to which students see issues as black and white terms and how they view authority. Relativism measures the extent to which students have discovered that alternative perspectives exist, but still believe they do not control their future themselves. Commitment indicates to what extent a student is willing to stand behind his/her own viewpoint despite the diversities in others. Finally, empathy surveys the students' feelings of responsibility to society. These four positions are congruent to those addressed in the literature review on Perry's scheme.

The Cronbach alpha coefficients for internal consistency were .81, .70, .76, and .73 for dualism, relativism, commitment, and empathy respectively. Revisions were conducted by Perry to improve reliability. The SID-II consisted of 101 items while the SID-IV consists of 115 items. The SID-IV is the fourth version of the instrument. It is more reliable as a measurement of cognitive development than previous versions. In the SID-IV, additional items were added under each sub-scale and a fifth sub-scale of "faking" was incorporated. The purpose of the fifth scale is to determine if a student's response to the items gives a fake appearance in favor of one of the stages. A score of 19 or greater on the fake sub-scale would indicate a need to disregard that score because the other four sub-scales contain invalid information. This instrument was used to assess a student's level of cognitive development (Appendix 2). Some research is concerned that the SID is not sensitive to stages beyond dualism (Stonewater, Stonewater, and Hadley, 1986; Allen, 1983). This research was interested in showing movement out of dualism without a strong interest in the exact resulting stage of the progression. However, due to the scoring nature of the SID-IV and the lack of ability to combine categories, progression was recorded in each stage. Students with a high "fake" score were eliminated from the study.

Miller and Smith (1989) assessed the prerequisite mathematics vocabulary for intermediate and college algebra students in order to observe any differences between the two groups of students. A convenience sample was used in their research formed by nine intermediate classes (162 students) and six college algebra classes (178 students). Each student was given a pre- and post-test on vocabulary deemed prerequisite for both courses. This test was created by reviewing mathematics textbooks for common vocabulary words. An initial list of 60 words was created. A single instructor, not involved in the study, rated the list. The instructor rated each word as easy, medium, or hard. From these ratings a list of 30 medium-rated words was created. Forty-three math instructors approved the final list as a list of prerequisite terms for college algebra. The test was administered to students on the first day of class. For students enrolled in DS099 (Intermediate Algebra) the pre-test mean was 15.0 on a 30-point scale and the posttest mean was 17.4. This eight percent increase in scores was not significant. A correlational technique was used to determine if prerequisite vocabulary knowledge was correlated to course grades. A weak correlation was found, $r = .21$. Due to this weak correlation and small increase in scores, the researchers concluded that students are not relying on vocabulary understanding and mathematics concepts to do mathematics. Miller and Smith (1989) argued that students are using rote memorization skills to produce patterns that lead to results. The study included a comparison of traditional and non-traditional students. Although entering scores for both groups were similar, the non-traditional students showed a greater gain in vocabulary knowledge at the end of the semester. This research was based on traditional mathematics teaching methods.

The aim of the current research was to explore the use of journal writing to introduce and reinforce mathematics vocabulary and concepts in order to increase vocabulary and cognitive development in developmental mathematics students. The vocabulary test used in this study provides a continuous value for each student's knowledge of mathematics vocabulary and was used to measure vocabulary development (appendix 3). Three questions were omitted from the test because the level of the questions was above Basic Algebra.

Variables

The independent variable in the research was vocabulary development through journal writing. The dependent variables analyzed in this research were cognitive development, achievement, and vocabulary acquisition. The variables were analyzed by looking at the following student data:

1. Pre-test CPT scores
2. Pre-test SID scores
3. Pre-test vocabulary scores

4. Post-test CPT scores
5. Post-test vocabulary scores
6. Post-test SID scores
7. Gender
8. Enrollment category (traditional and non-traditional)
9. Classification

Cognitive development was assessed by looking at movement between or within the four sub-divisions of development determined by the SID-IV. CPT scores were used to measure achievement and the vocabulary test was used to obtain a measure of vocabulary acquisition.

Design

On the first day of the semester, each student in both groups filled out a background information sheet to provide demographic information. This information was validated using information on file with the registrar's office. Specific characteristics gathered were age, gender, completed college credit hours (classification), and number of years since the last enrollment in a mathematics class. Gender was studied since females tend to be reflective learners and males seem to be more active oriented learners (Baxter-Magolda, 1988). Due to the reflective nature of the journals, this research would suggest that females would benefit more from being requested to make journal entries. Belenkey and others (1986) would also agree that due to the inability of women in the silent stage to find meaning in the words of others, a lack of focus on vocabulary understanding and development leaves them passive, reactive and dependent on authority, which in turn holds them in a dualism stage of cognitive development. Age and number of years since last math class were used to determine the type of student. Non-traditional or adult students are those students above the age of 22 and traditional students are those between the ages of 17 and 22 (Kasworm, 1990). Non-traditional students can also be classified as those who have not taken classes for more than 4 years. The type of student was investigated because the research shows that the adult learner, non-traditional student, progresses in cognitive development more readily than the traditional student due to their greater culmination of past experiences (Cameron, 1984). The classification was used because college freshmen are more apt to be in the dualistic stage of cognitive development as opposed to upperclassmen (Cameron, 1984).

To insure homogeneity of groups in initial achievement abilities, CPT scores were obtained from the assessment office. Most students had a CPT score on file. Those students with missing scores were asked to set up appointments to be tested at the assessment office within the first week of class. The vocabulary test was administered on the second day of class to obtain a measure of pre-vocabulary knowledge. To assess equal backgrounds in cognitive development, the SID-IV was administered to both groups on the fourth day of class. These instruments were given on different days in order to avoid any cross contamination of instruments.

Additional assignments of journal writing to emphasize vocabulary and concept development in each chapter were given to the 11:00 class as the experimental treatment. These journal assignments were given toward the beginning of each chapter and collected two days prior to each chapter test. This allowed the instructor one day to provide feedback and return the journals before the test. A participation grade was given, disregarding grammatical and spelling errors. Provided that the students made an honest attempt on every prompt, they received full credit for the journal assignment. Since a few questions on vocabulary were on each chapter test for both groups, the instructor guided the control group to view vocabulary also. Instead of giving them a guide with prompts, they were instructed to look at the words listed in the chapter review in the book. All other assignments remained the same. On review days for the test, the control group was given the opportunity, but not prompted, to ask any questions over the chapter or vocabulary in the book review. The journals were discussed in the experimental group and then they were able to ask questions over the rest of the chapter.

Post-testing for each group was done during the last full week of classes in the semester. The vocabulary test was given on Monday of the last week. It was used to show a change in vocabulary acquisition. The SID-IV was administered on the last Thursday of the semester. The post-SID score showed movement between or within levels of cognitive development. Post-testing with the CPT was conducted on the last Friday of the semester. These scores were used to measure any gain in achievement.

Data Analysis

Bar graphs and averages are used to illustrate a comparison between groups on demographics and pre- and post-test averages. The mean, standard deviation, median, and range are given for pre- and post-scores. The percentage of students at each stage noted by the SID-IV is a more important statistic than the average for this variable, so a percentage chart was provided.

A t-test for correlated means was used to compare the pre- and post-test scores in cognitive development within groups. This was used to test for a significant change in cognitive development within groups. A second t-test was calculated to compare the post-test scores of both groups. If the treatment was successful, a significant difference between the groups should be revealed. Post-testing was used to show a significant increase or change in achievement.

Ethics and Human Relations

The researcher scored and recorded the results of the SID-IV and vocabulary measures. The assessment center scored the CPT test on the computer. These scores were kept confidential. All scores were entered into a computer requiring a personal password for access. The hard copies of results were stored in a locked file cabinet in the researcher's office or at the residence of the researcher after a job change and relocation to another state. Results of specific individuals were not, nor will not, be discussed or shared in any way with others. To insure confidentiality, a random four-digit number was assigned to students as opposed to using their names.

Students gave informed consent to being part of this research by signing a form at the beginning of the course (Appendix 5). Approval was obtained from both the university of the research and the University of Oklahoma's protection of human subjects committees (Appendix 6). The teaching of vocabulary as part of the Basic Algebra course did not interfere with the instruction of the course content. The use of journals and emphasis on language development and vocabulary with the experimental group did not detract from or interfere with instruction received by the control group. This study closely adhered to the guidelines and ethical practices established by the AERA and the Institutional Review Board of the University of Oklahoma. Permission was obtained by the authors to use the SID-IV developed by Irwin and the vocabulary test developed by Miller and Smith.

CHAPTER IV

RESULTS

In the previous chapter, a design for the present study was outlined. The quasi-experimental design included several measures including the SID-IV to measure students' levels of cognitive development as indicated by Perry's model, a vocabulary test to provide information in the area of vocabulary development, and the CPT test to measure achievement on the groups being studied. A review of the literature was provided to discuss the connections between language and cognitive development. It also provided a rationale for implementing journal writing as the agency to access and develop language for classroom discourse and to facilitate change in cognitive levels. The question posed by this research is: How does focusing on language through a journal writing process and classroom discourse impact the cognitive development, achievement, and vocabulary development of developmental mathematics students?

This chapter describes the results of incorporating vocabulary instruction and journal writing on cognitive development, vocabulary development, and achievement of students enrolled in the developmental mathematics course Basic Algebra. Pre- and post-test analyses, as well as a qualitative analysis of journal writings, allowed for comparisons of the experimental and control groups in order to study: (1) the relationship between learning mathematics vocabulary and cognitive development, (2) the relationship between learning mathematics vocabulary and achievement, (3) the impact of learning mathematics vocabulary for nontraditional, adult learners as compared to traditional college-aged students, and (4) the effect of learning mathematics vocabulary through journal writing for male and female students.

Demographic Information

This study focused on two sections of Basic Algebra offered in the Spring of 2000 at Heartland University. The original enrollments of each of these sections were sixteen and twenty, but due mainly to failure to complete the course and partly to incomplete data, the final analysis consisted of eighteen students. The final analysis of these two sections consisted of seven students who were enrolled in the control group and eleven students in the experimental group. The control group consisted of four females and three males, while the experimental group consisted of six females and five males. The control group consisted of six freshmen and one sophomore, while the experimental group consisted of nine freshmen, one sophomore, and one junior. The majority of students attending the University are from the surrounding rural areas; therefore, participants were from similar socioeconomic and cultural backgrounds. However, one participant in the control group was from Africa. The participants were classified as traditional or non-traditional according to their ages. Kasworm (1990) defines the traditional student as that person who is 17 – 22 years old. In the control group, three students were traditional and four students were non-traditional. In the experimental group, seven students were traditional and two were non-traditional. Two students in the experimental group failed to provide information about their age and therefore were not used in this category. Their scores were included in other analysis.

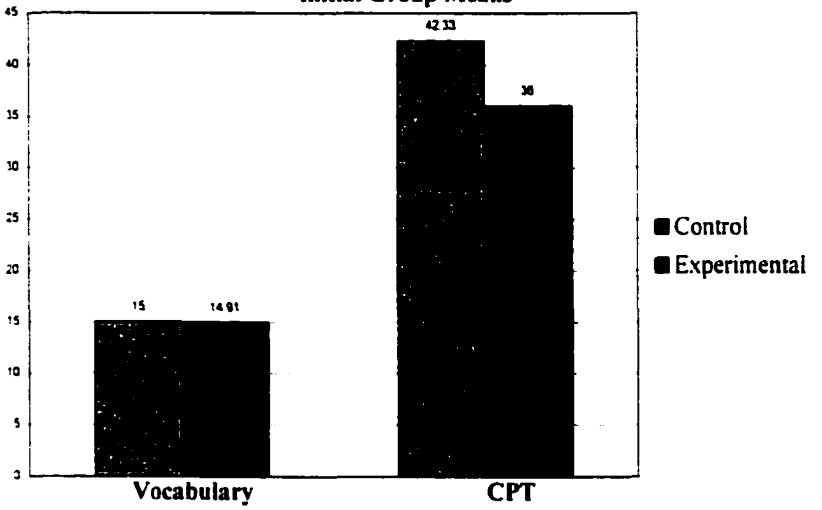
Initial Vocabulary Development and Achievement

Univariate analysis was performed to obtain the means, standard deviations, medians, and ranges of pre-test scores for the control and experimental groups in order to characterize the groups by these measures. Some students did not take all tests due to recurring absences or failure to complete the course. Their scores were treated as missing data and dropped from the analysis. The results of the vocabulary and CPT pre-tests for each group are located in Table 2.1 and Chart 2.1. The means for this sample on the vocabulary pre-tests (15.0 and 14.91) are comparable to the mean obtained by Miller and Smith (15.0). A lower mean was expected for this study since Miller and Smith used the vocabulary test for students at the intermediate algebra level, which is the course that follows basic algebra.

Table 2.1
Descriptive Statistics

	Mean	S.D.	Median	Range
Control Group (n = 7)				
Vocabulary Pretest	15	2.58	15.0	7
CPT Pretest	42.33	17.69	37.5	49
Experimental Group (n = 11)				
Vocabulary Pretest	14.91	3.24	15.0	12
CPT Pretest	36.00	6.48	34.0	15

Chart 2.1
Initial Group Means



The means of the CPT for both groups are also in the range of 0–52 which is the range selected by the university on which the study was completed to determine student placement in basic algebra. The university selected this range by comparing cut off scores for basic, intermediate, and college algebra at other institutions of higher education in the region of this study.

The data collected from the pre-tests for vocabulary and achievement are continuous. The means and standard deviations were calculated to see that the data followed a normal distribution. Approximately 68 percent of the students scored within one standard deviation of the mean and approximately 95 percent of the students scored within two standard deviations of the mean on the CPT and vocabulary tests for each group. The data met the criteria for a normal distribution, therefore, a t-test for correlated means was performed to make the initial analyses. Although the data sample size did not meet the required assumptions for use of a t-test, the t-test is acceptable in educational research. Educational research has been criticized for the *power* of its results (Gall, Borg, & Gall, 1996). It is a fact that the *power* of statistical results increases with sample size. However, statisticians have found that t-tests provide accurate estimates of statistical significance even under conditions of substantial violation of the assumptions (Boneau, 1960). Educational researchers generally accept a finding as significant when using a t-test if the significance level of $p < .05$ (Clowles & Davis, 1982). The t-tests calculated on this data determined that the differences between the control and experimental groups for pre-vocabulary ($t = 0.07$, $p = 0.951$) and pre-CPT ($t = 0.840$, $p = 0.434$) were not significant. So we can claim that the classes are comparable with respect to vocabulary development and achievement at the beginning of the research. Table 2.2 contains a summary of the above-mentioned data.

Table 2.2
T-Tests on Vocabulary and CPT

	t-value	p value
Pre- Vocabulary	t = 0.07	p = 0.951
Pre- CPT	t = 0.84	p = 0.434

Pre-Test Cognitive Development

To determine the initial level of cognitive development for each class, the SID-IV was calculated according to the Scale of Intellectual Development Manual. To insure anonymity, each student was assigned a random four-digit number generated by a spreadsheet program. The standard scores (SS) in each of the four subdivisions were determined by using the raw scores and the following calculation methods:

$$SS = AX + B$$

$$A = \frac{10}{\text{raw standard deviation}}.$$

$$B = 50 - A \text{ times the Raw Mean.}$$

According to the test manual, the category with the highest standard score is the best predictor of the cognitive development for that student. Champaign (1982) suggests that developmental educators focus on the three general perspectives of student development rather than on the exact position of the development. The SID manual also stated that it is rare for an undergraduate student to score highest at the empathy stage of development. Therefore, for this research, only three stages of development were used: dualism, relativism, and commitment. In the dualism stage, students view knowledge and authority as absolutes that are dualistic: right/wrong, good/bad, absolute/relative. They believe knowledge is acquired only through an expert or teacher and view that teacher or expert as the authority. As students progress to the relativism stage, they begin to recognize diversity of opinions depending on the context. They realize that authority figures may not have all the right answers and go to alternative sites such as the textbook, peers, or even the Internet for clarification. Students in this stage realize there can be many forms of the correct answer and many processes to work the same problem. They realize that the context of the problem often dictates the process used. In the last category, commitment, students are prepared to make choices on their own and act accordingly. Some research is concerned that the SID is not sensitive to stages beyond dualism (Stonewater, Stonewater, and Hadley, 1986; Allen, 1983). The current research was interested in showing movement out of dualism without a strong interest in the exact resulting stage of the progression. However, due to the scoring nature of the SID-IV and the lack of ability to combine categories, progression was recorded initially in each of the three stages mentioned above.

Student number 9162, 8700, and 5883 scored highest at the empathy stage. For these students, the next highest score was used for their cognitive development as suggested by the developers of the test. Two students scored high on the fake level. They are not included in the study. The standard scores for each student and each division are given in table 2.3.

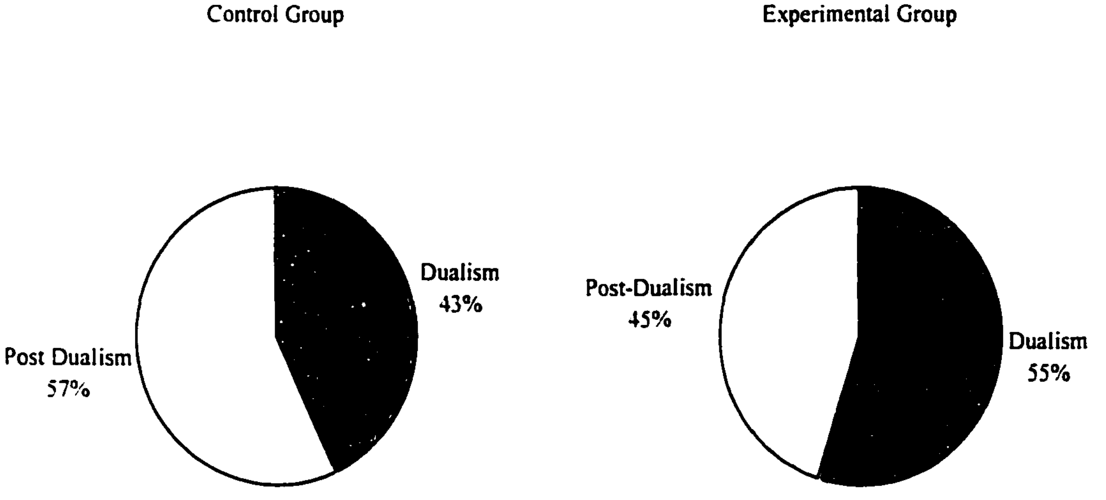
Table 2.3
Initial Individual Cognitive Development

	Dualism	Relativism	Commitment	Empathy
Control Group (n = 7)				
5231	53.78	52.05	**69.95***	50.9
5057	67.53	41.61	**71.84***	53.96
6447	**59.4***	44.22	57.44	46.82
6086	61.9	49.44	**85.28***	65.18
9818	65.03	32.04	**71.84***	51.92
1229	**73.15***	49.44	66.08	59.06
0533	**78.15***	44.22	49.76	43.76
Experimental Group (n = 11)				
0515	**75.03***	60.75	54.56	59.06
9162	**62.53***	56.4	57.44	72.32
9935	**62.53***	62.46	44	39.68
8700	52.53	**58.12***	52.64	65.18
5883	52.53	45.96	**53.6***	61.1
6720	51.28	57.27	**81.44***	61.1
4367	64.4	39	**75.68***	46.82
8639	**64.4***	45.09	63.2	60.08
3321	**81.9***	60.75	47.84	59.06
3267	59.4	45.09	**67.04***	54.98
3779	**60.03***	52.05	57.44	40.7

* Level of Cognitive Development used for individual calculations

The classes were compared on cognitive development in two ways. Since this research is interested in movement out of dualism, the classes were first compared looking at the percentage of students in dualism and beyond dualism. The control group consisted of forty-three percent (three students) at the dualism stage and fifty-seven percent (four students) at stages beyond dualism. The experimental group contained fifty-five percent (six students) at the dualism stage and forty-five percent (five students) at stages beyond dualism. Chart 2.3 gives the percentage of students at these two levels of cognitive development.

Chart 2.3
Percent of Students at Each Initial Stage

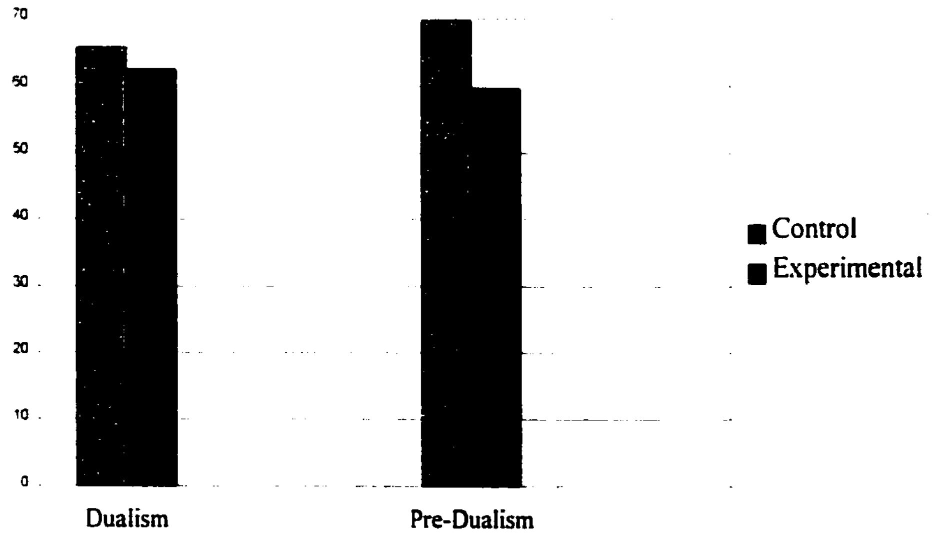


To compare the classes further, mean scores for the subdivisions were calculated. These means scores are given in Table 2.4 and Chart 2.4. Mean scores were compared in order to measure any movement within a stage as opposed to out of dualism or between stages. The mean score for the control group was higher in commitment. The higher level of commitment for this class could have been due to the difference in the average ages of the two classes. The average age of the control group was 24 and the average age of the experimental group was 22. The significance of these age differences can be attributed to the type of student (traditional or non-traditional) and their potentially different life experiences and situations. The SID-IV gives a measure of cognitive development based on all life experiences, not just mathematics. The majority of students in both groups were either in the dualism or the commitment stage. Therefore, when groups are compared by means, these two stages will be used to measure the level of cognitive development at the dualism stage or beyond dualism (commitment stage) in further analysis. Since the SID used a different sampling of questions for each of these stages, students may show movement within a stage as well as between stages.

Table 2.4
Initial Group Cognitive Development

	Mean	S.D.	Range
Control Group (n = 7)			
Dualism	65.56	8.27	24.38
Commitment	69.65	11.61	35.52
Experimental Group (n = 11)			
Dualism	62.41	9.37	30.63
Commitment	59.54	11.42	37.44

Chart 2.4
Initial Group Cognitive Development Means



In comparing the two classes with the initial cognitive scores, a t-test for correlated means indicated there was not a significant difference for pre-dualism ($t = 0.747$, $p = 0.467$) or for pre-commitment ($t = 1.820$, $p = 0.088$). Thus, the classes are comparable with respect to cognitive development and the dualism and commitment scores will be used for further analysis. Later discussion will refer to initial cognitive development as pre-dualism or pre-commitment. Table 2.5 contains a summary of the above-mentioned data.

Table 2.5
T-Tests on Cognitive Levels

	t-value	p value
Pre- Dualism	t = 0.75	p = 0.467
Pre- Commitment	t = 1.820	p = 0.088

Analysis by Student Type, Gender, and Classification

Data were further analyzed looking at groups according to student type (traditional or non-traditional), gender (male or female) and classification (freshman, sophomore, junior, or senior). Comparing the data for the non-traditional students in the control and experimental groups, by using a t-test, no significant differences were found between the groups on the variables: pre-CPT ($t = 1.001$, $p = 0.385$), pre-vocabulary ($t = -0.562$, $p = 0.605$), pre-dualism ($t = 0.827$, $p = 0.545$) and pre-commitment ($t = -0.79$, $p = 0.470$). Comparing the data for the traditional students in the control and experimental group, again no significant differences were found between the groups on the variables: pre-CPT ($t = 0.883$, $p = 0.535$), pre-vocabulary ($t = -0.173$, $p = 0.870$), pre-dualism (t = 0.609, p = 0.589), and pre-commitment (t = 1.837, p = 0.096). Tables 2.6 and 2.7 contain this data.

Table 2.6
Non-Traditional Students

	t-value	p value
Pre- CPT	t = 1.001	p = 0.385
Pre- Vocabulary	t = -0.562	p = 0.605
Pre- Dualism	t = 0.827	p = 0.545
Pre-Commitment	t =-0.797	p = 0.470

Table 2.7
Traditional Students

	t-value	p value
Pre- CPT	t = 0.883	p = 0.535
Pre- Vocabulary	t = -0.173	p = 0.870
Pre- Dualism	t = 0.609	p = 0.589
Pre-Commitment	t = 1.837	p = 0.096

Comparing the data for males and females in the control and experimental groups by using a t-test, no significant differences were found between the female students on the variables: pre-CPT (t = 0.396, p = 0.706), pre-vocabulary (t = -0.309, p = 0.765), and pre-dualism (t = 0.755, p = 0.472). There was a significant difference for the females on the variable pre-commitment (t = 2.664, p = 0.029), however. The control group females (n = 4) had a pre-commitment mean of 76.640 and the experimental group females (n = 6) had a mean of 60.480. This difference may be present due to the average age of the females in the two groups (24, control; 21, experimental) and the probable affect of age on cognitive development. Comparing the data for the male students in the control and experimental group, again using a t-test, no significant differences were found between the groups on the variables: pre-CPT (t = 1.076, p = 0.331), pre-vocabulary (t = 0.777, p = 0.466), pre-dualism (t = 0.273, p = 0.794), and pre-commitment (t = 0.210, p = 0.840). Tables 2.8 and 2.9 contain this data.

Table 2.8
Female Students

	t-value	p value
Pre- CPT	t = 0.396	p = 0.706
Pre- Vocabulary	t = -0.309	p = 0.765
Pre- Dualism	t = 0.755	p = 0.472
Pre-Commitment	t =2.664	p = 0.029*

Table 2.9
Male Students

	t-value	p value
Pre- CPT	t = 1.076	p = 0.331
Pre- Vocabulary	t = 0.777	p = 0.466
Pre- Dualism	t = 0.273	p = 0.794
Pre-Commitment	t = 0210	p = 0.840

The data were also compared, by grouping the students according to classifications. Due to the lack of availability of a test for low numbers in the sophomore (n = 3) and junior classifications (n = 1), only the freshmen (n = 14) were compared. In comparing the data for the freshman classification in the control (n = 5) and experimental (n = 9) groups by using a t-test, no significant differences were found between the freshmen students on the variables: pre-CPT (t = 0.322, p = 0.755), pre-vocabulary (t = 0.222, p = 0.825), pre-dualism (t = 0.819, p = 0.429) or pre-commitment (t = 1.693, p = 0.116). Table 2.10 contains this data.

Table 2.10
Freshman

	t-value	p value
Pre- CPT	t = 0.322	p = 0.755
Pre- Vocabulary	t = 0.222	p = 0.825
Pre- Dualism	t = 0.819	p = 0.429
Pre-Commitment	t =1.693	p = 0.116

Data were also analyzed to inspect differences within the experimental group. Significant differences were found in the experimental group between traditional (n = 7) and nontraditional (n = 2) students for the variable pre-CPT (t = 3.040, p = 0.024) and pre-commitment (t = -4.355, p = 0.002). The traditional students had a mean CPT score of 37.9 and the nontraditional students had a mean score of 29.5. The traditional students had a mean pre-commitment score of 55.307 and the nontraditional students had a mean score of 78.560. No significant differences were found for the variables pre-vocabulary (t = -0.863, p = 0.431) and pre-dualism (t = 0.765, p = 0.545). Data is given in Table 2.11.

Table 2.11
Experimental Group by Student Type

	Traditional	Non-traditional
Means		
Pre-CPT	37.9	29.5
Pre- Commitment	55.307	78.560
Correlations		
Pre- CPT	t = 3.040	p = 0.024*
Pre- Vocabulary	t = -0.863	p = 0.431
Pre- Dualism	t = 0.765	p = 0.545
Pre-Commitment	t = -4.355	p = 0.002*

A single ANOVA was used to analyze the data when grouped according to gender. Using an ANOVA allowed for the investigation of groups and gender simultaneous without having to manually manipulate the data. In the experimental group: males (n = 5) and females (n = 6), significant differences were not found between genders for the variables pre-CPT (F = .242, p = .637), pre-vocabulary (F = 0.009, p = 0.925), pre-dualism (F = 1.102, p = 0.321) or pre-commitment (F = 0.050, p = 0.828). Table 2.12 contains this data.

Table 2.12
Experimental Group
ANOVA results when grouped by Gender

	F ratio	P value
Pre-CPT	F = 0.242	P = 0.637
Pre-vocabulary	F = 0.009	P = 0.925
Pre-Dualism	F = 1.102	P = 0.321
Pre-Commitment	F = 0.050	P = 0.828

Based on initial comparisons of pre-experimental data, the special populations of nontraditional, traditional and males in the experimental group were equivalent on all independent variables. Significant differences were found for the females in the experimental group on the variable pre-commitment. This difference may be present due to differences in the ages of the females. The average age of females in the control group was 24, while the average age in the experimental group was 21. There were no significant differences on the other independent variables for this group. When comparing nontraditional and traditional students within the experimental group, again there was a significant difference for the variable pre-commitment, which may be attributed to age differences. Another significant difference between the nontraditional and traditional students was found on the variable pre-CPT. This may be due to the time that has passed since the nontraditional students participated in a mathematics class.

Experimental Intervention

Additional assignments of journal writing to emphasize vocabulary and concept development in each chapter were given to the experimental group as the instrument of change for the experiment. These journal assignments were given toward the beginning of each chapter. The journals include prompts that directed students to define terms, clarify procedures or different algorithmic processes, and explain a concept in detail. The students worked at their own pace and on their own time to complete the journals during the time when the material for each chapter was presented. The journals were collected two days prior to each chapter test. This allowed the researcher a day to provide written feedback and return the journals before the test. A participation grade was given, disregarding grammatical errors, spelling errors, and wrong answers. Provided that the students made an honest attempt on every prompt, they received full credit for the journal assignment. While the experimental group was given a journal assignment to guide their vocabulary and concept development, the control group was directed to look at the vocabulary list in the chapter review to make sure they understood these concepts. Both classes discussed vocabulary and concepts on the day in which they reviewed for chapter tests. See Appendix 10 for a sample of a student's completed journal exercise.

Experimental Results

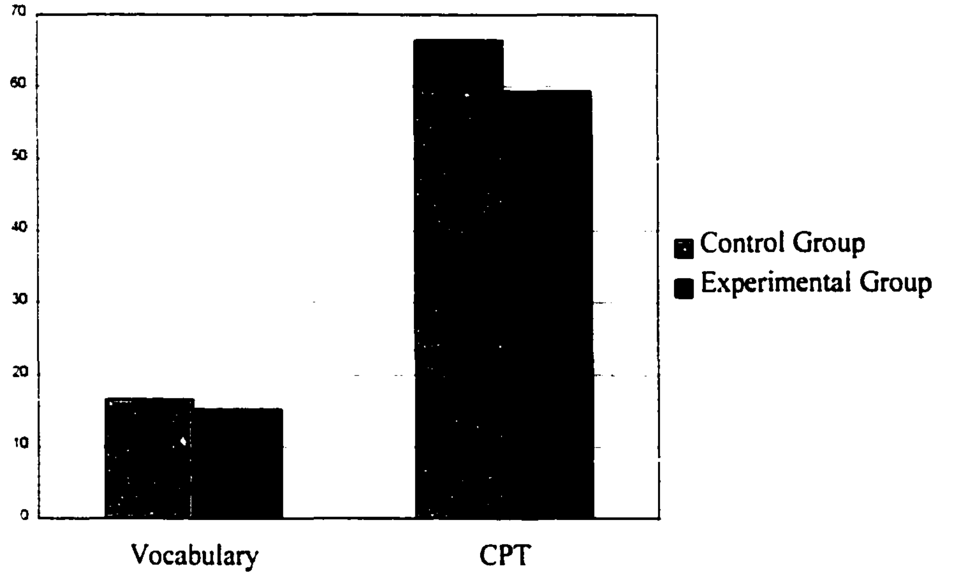
At the end of the semester, univariate analyses were performed to obtain the means, standard deviations, medians, and ranges of post-test scores for the control and experimental groups in order to investigate the results of the experimental treatment. The results of the vocabulary and CPT post-tests for each group are summarized in Table 3.1

and Chart 3.1. These figures indicate the final measures for the variables vocabulary and achievement.

Table 3.1
Descriptive Statistics

	Mean	S.D.	Median	Range
Control Group (n = 7)				
Vocabulary Posttest	16.57	3.41	17.0	9
CPT Posttest	66.5	19.79	67.5	65
Experimental Group (n = 11)				
Vocabulary Posttest	15.18	2.36	16.0	9
CPT Posttest	59.27	22.68	55.0	76

Chart 3.1
Final Group Means



A t-test for correlated means was performed on the post-tests for each group. The t-tests determined that the differences between the control and experimental groups for post-CPT ($t = 0.186$, $p = 0.859$) were not significant. In comparing the two classes with the post-vocabulary there was a significant difference ($t = 4.392$, $p = 0.002$). Table 3.2 contains a summary of the above-mentioned data.

Table 3.2
T-Tests on Vocabulary and CPT

	t-value	p value
Post – Vocabulary	t = 4.392	p = 0.002*
Post – CPT	t = 0.186	p = 0.859

Cognitive Development

To determine the final level of cognitive development for each class, the SID-IV was again administered and calculated and the standard scores in each of the four subdivisions were determined. The category with the highest standard score was again used as the best predictor of the cognitive development for that student. The standard scores for each student and each division are given in Table 3.3.

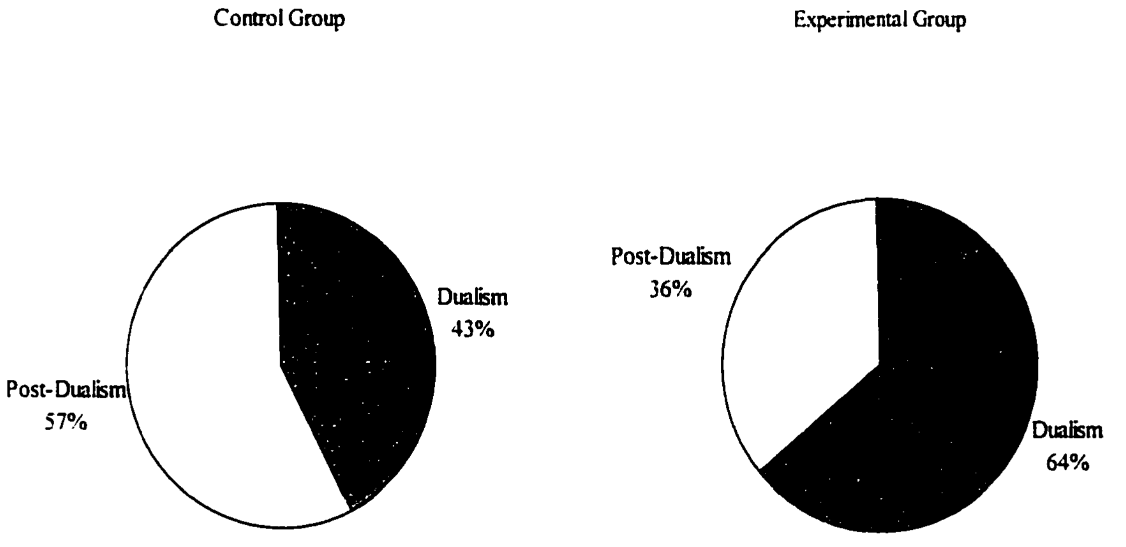
Table 3.3
Final Individual Cognitive Development

	Dualism	Relativism	Commitment	Empathy
Control Group (n = 7)				
5231	48.78	40.74	**68.00***	42.72
5057	**72.53***	45.96	58.4	52.94
6447	54.4	46.83	**68.0***	66.2
6086	72.53	45.96	**84.32***	60.08
9818	64.4	38.13	**69.92***	46.82
1229	**75.65***	43.35	67.04	56.0
0533	**79.4***	52.92	54.56	51.92
Experimental Group (n = 11)				
0515	**70.03***	59.88	44.96	51.92
9162	**68.78***	44.22	58.4	69.26
9935	**64.4***	57.27	45.92	43.76
8700	56.9	**57.27***	54.56	59.06
5883	58.15	37.26	**65.12***	50.9
6720	51.9	45.96	**81.44***	64.16
4367	73.15	39.0	**77.6***	50.9
8639	**74.4***	47.7	66.08	57.02
3321	**80.03***	68.58	44.96	56.0
3267	**76.9***	52.05	50.72	49.88
3779	**63.15***	45.96	55.52	45.8

*Level of cognitive Development used for individual calculations.

The classes were again compared by looking at the frequency distribution and means. The control group consisted of three students at the dualism stage and four students at post dualism stages. The experimental group contained seven students at the dualism stage and four students at post dualism stages. Chart 3.3 gives the frequency distribution.

Chart 3.3
Percentage of Students at Final Stages



The final cognitive levels were also viewed in comparison with the initial level for each student. An "A" notes the initial level of cognitive development and a "B" notes the final level. An asterisk is used to denote those students who scored higher in empathy thus causing a reassignment in cognitive level. Tables 3.4 and 3.5 show the comparison of initial and final levels for both groups.

Table 3.4
Comparison of Cognitive Development
Control Group

	Student Type	Dualism	Relativism	Commitment
5231	Traditional			A, B
5057	Non-traditional	B		A
6447	Non-traditional	A		B
6086	Non-traditional			A, B
9818	Non-traditional			A, B
1229	Traditional	A, B		
0533	Traditional	A, B		

A- Initial Cognitive Development Stage
B- Final Cognitive Development Stage
** Relativism and Commitment are Post-Dualistic Stages.

Table 3.5
Comparison of Cognitive Development
Experimental Group

	Student Type	Dualism	Relativism	Commitment
0515	Traditional	A, B		
9162	Traditional	A*, B*		
9935	Traditional	A, B		
8700	Traditional		A*, B*	
5883	Traditional			A*, B
6720	Non- traditional			A, B
4367	Non-traditional			A, B
8639	Traditional	A, B		
3321	Traditional	A, B		
3267	Traditional	B		A
3779	Traditional	A, B		

A- Initial Cognitive Development Stage
B- Final Cognitive Development Stage
* - Assignment of Stage Adjusted Due to High Score in Empathy
** - Relativism and Commitment are Post-Dualistic Stages.

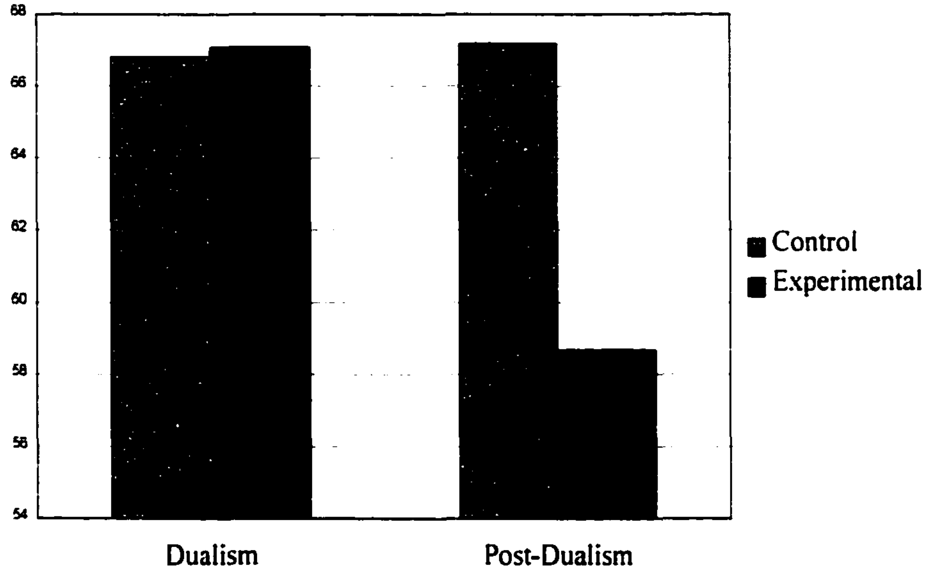
Students 3267 and 5057 show signs of retreat. Students who retreat to a former stage may be showing signs of disequilibrium caused by the metacognition associated with journal writing. These students may have also had a life-changing experience during the semester that cause their answers on the SID to change. Further research data would be needed to explore this difference in initial and final scores.

To compare the classes, mean scores for the subdivisions, dualism and commitment, were calculated. These means scores are given in Table 3.6 and Chart 3.6. The mean scores in both categories were used in order to investigate any movement for each group within as well as between the levels of cognitive development.

Table 3.6
Final Levels of Cognitive Development

	Mean	S.D.	Range
Control Group (n = 7)			
Dualism	66.81	8.27	24.38
Commitment	67.18	11.61	35.52
Experimental Group (n = 11)			
Dualism	67.07	9.37	30.63
Commitment	58.66	11.42	37.44

Chart 3.6
Final Cognitive Development Means



The mean score for the control group was again higher in Post-Dualism (commitment). The higher level of commitment for this group could still be attributed to the difference in the average ages of the two groups. Since the SID measures cognitive development for all aspects of life, a student who is older would have more life experiences that could impact cognitive levels. Therefore, both the dualism score and the commitment score will be used for further group analysis.

A t-test for correlated means was performed on the post-tests for each group. The t-tests determined that the differences between the control and experimental groups for post dualism scores ($t = -0.050$, $p = 0.961$) and post-commitment scores ($t = 1.523$, $p = 0.147$) were not significant. Table 3.7 contains a summary of the above-mentioned data.

Table 3.7
T-Tests on Post-Dualism and Post-Commitment

	t-value	p value
Post – Dualism	t = -0.050	p = 0.961
Post – Commitment	t = 1.523	p = 0.147

Although the t-test shows that there were no significant difference between the groups for cognitive development, additional tests were run on the groups individually to further investigate the research question: How does focusing on language and classroom discourse impact the cognitive development of developmental mathematics students? A t-test was run on each group separately to compare pre- and post-test scores for dualism and commitment. According to the t-test results, significant differences were not present for the control group on the variable dualism ($t = -0.596$, $p = 0.573$) or commitment ($t = 0.862$, $p = 0.422$). However, when looking at Chart 3.4, it is obvious that two students did change in cognitive levels. These individual changes were not significant enough to show a difference for the entire group. The experimental group did not have a significant change for commitment ($t = 0.403$, $p = 0.695$) according to the t-tests, but there was a significant difference in the dualism scores ($t = -2.520$, $p = 0.030$). Table 3.8 contains these results.

Table 3.8
Comparison of Dualism and Commitment

	t-value	p value
Control Group		
Dualism	t = -0.596	p = 0.573
Commitment	t = 0.862	p = 0.422
Experimental Group		
Dualism	t = -2.520	p = 0.030*
Commitment	t = 0.403	p = 0.695

When comparing the control and experimental groups on the measures for cognitive development. no significant differences were found with quantitative analysis. The control group has a higher mean score in post dualism, but without more data, it is inconclusive to say that this was solely a factor of age differences. When the data for each group was examined to investigate differences within the groups, there was a significant finding. The experimental group had a significant change for post-dualism. This suggests that the journal writing did cause a significant change in cognitive development within the dualism stage for the experimental group. In this group, students fell deeper into dualism. Table 3.5 shows that one student retreated to dualism from a post-dualism stage. Students who retreat to a former stage or fall deeper into a current stage may be showing signs of disequilibrium caused by the metacognition associated with journal writing. These results will be investigated further with qualitative analysis.

<u>Subgroup Analysis</u>

Data were further analyzed looking at groups according to student type (traditional or non-traditional). Comparing the data for the non-traditional students in the control and experimental groups, no significant differences were found between the groups on the variables: post-CPT (t = 0.328, p = 0.759), post-dualism (t = 0.357, p = 0.727) and post-commitment (t = -1.154, p = 0.313). Significant differences were found for the variable, post-vocabulary (t = 4.679, p = 0.019). Comparing the data for the traditional students in the control and experimental group, again no significant differences were found between the groups on the variables: post-CPT (t = 0.471, p = 0.649), post-vocabulary (t = 2.474, p = 0.083), post dualism (t = -0.014, p = 0.990), and post-commitment (t = 1.715, p = 0.117). Tables 3.9, 3.10, 3.11 and 3.12 contain this data.

Table 3.9
Non-Traditional Students

Means	Control	Experimental
Post-CPT	66.00	58.50
Post-Vocabulary	18.67 *	7.5 *
Post-Dualism	65.97	62.53
Post-Commitment	63.02	54.03

Table 3.10
Non-Traditional Students

T-test	t-value	p value
Post – CPT	t = 0.328	p = 0.759
Post – Vocabulary	t = 4.679	p = 0.019 *
Post – Dualism	t = 0.300	p = 0.804
Post – Commitment	t = -1.154	p = 0.313

Table 3.11
Traditional Students

Means	Control	Experimental
Post-CPT	67.500	59.444
Post-Vocabulary	14.33	9.11
Post-Dualism	67.94	68.08
Post-Commitment	70.160	79.520

Table 3.12
Traditional Students

T-test	t-value	p value
Post – CPT	t = 0.471	p = 0.649
Post – Vocabulary	t = 2.474	p = 0.083
Post – Dualism	t = -0.014	p = 0.990
Post – Commitment	t = 1.715	p = 0.117

Post scores were examined using a single ANOVA to analyze the data when grouped according to gender. The control group contained three males and four females. The experimental group contained five males and six females. No significant differences were found between the classes when grouped by gender for post-CPT ($F = 0.407$, $p = 0.533$), post-vocabulary ($F = 0.000$, $p = 0.983$), post-dualism ($F = 2.638$, $p = 0.139$), and post-commitment ($F = 0.992$, $p = 0.335$). Results of the ANOVA can be found in Table 3.13.

Table 3.13
ANOVA results when grouped by Gender

	F ratio	P value
Post-CPT	F = 0.407	P = 0.533
Post-vocabulary	F = 0.000	P = 0.983
Post-Dualism	F = 2.638	P = 0.139
Post-Commitment	F = 0.992	P = 0.335

Data were further analyzed looking at groups according to classification. Comparing the data for the freshmen in the control and experimental groups, no significant differences were found between the groups on the variables: post-CPT (t = 0.429, p = 0.675), post-dualism (t = 0.356, p = 0.728), and post-commitment (t = 1.571, p = 0.142). Significant differences were found for the variable, post-vocabulary (t = 3.735, p = 0.003). This difference may be reflective of the same differences found when students were compared according to type: nontraditional and traditional. A higher percentage of freshmen in the control group were nontraditional (50%) while a higher percentage of the freshmen in the experimental group were traditional (89%). Table 3.14 and 3.15 contains these data.

Table 3.14
Freshmen

Means	Control	Experimental
Post-CPT	63.40	57.89
Post-Vocabulary	16.25 *	9.0 *
Post-Dualism	70.90	69.19
Post-Commitment	66.46	56.48

Table 3.15
Freshmen

T-Test	t-value	p value
Post – CPT	t = 0.429	p = 0.675
Post – Vocabulary	t = 3.735	p = 0.003 *
Post – Dualism	t = 0.356	p = 0.728
Post – Commitment	t = 1.571	p = 0.142

This analysis of variables between the control and experimental groups suggests that significant differences exist for nontraditional students. The nontraditional students in the control group had a higher post-vocabulary mean than the nontraditional students in the experimental group. Further research would need to be conducted to investigate this difference.

Within-group Analysis

Both groups were compared for within group differences. The groups were first examined for gender differences. Separate t-tests for correlated means were calculated with pre- and post-test scores for each of the variables: CPT, vocabulary development, and cognitive development. Separate t-tests were used for the dualism and commitment stages to investigate cognitive development. A significant difference was not found for the variable CPT for females ($n = 4$, $t = -1.839$, $p = 0.207$) nor for the males ($n = 3$, $t = -1.476$, $p = 0.379$) in the control group. However, a close to significant difference was found for the variable CPT for females in the experimental group ($n = 6$, $t = -2.864$, $p = 0.064$) and for males in the experimental group ($n = 5$, $t = -2.721$, $p = 0.053$). A significant difference was not found for the variable vocabulary for females ($t = -1.00$, $p = 0.423$) nor for the males ($t = 0.000$, $p = 0.983$) in the control group. However, a significant difference was found for the variable vocabulary for females in the experimental group ($t = 6.047$, $p = 0.002$) and males in the experimental group ($t = 3.834$, $p = 0.031$). Comparing the changes in the pre- and post-test vocabulary scores for the gender subgroup in the experimental group, one sees a drop in vocabulary for the males, but a tremendous increase in the vocabulary for the females. Means for the groups were calculated and given in table 3.16 and 3.17 and Chart 3.17.

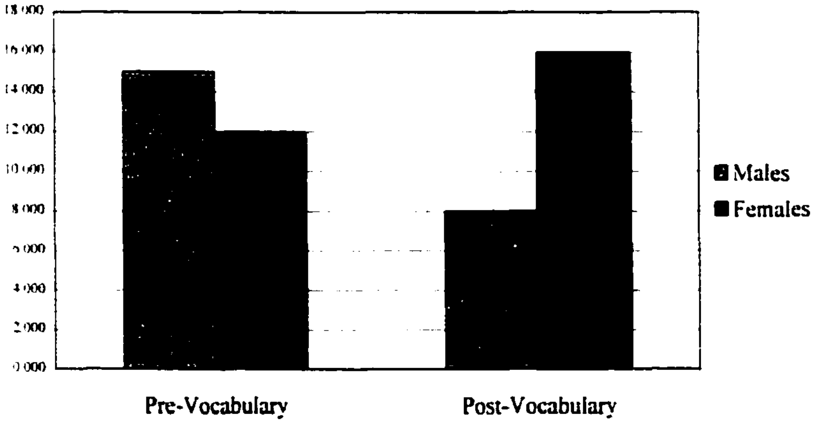
Table 3.16
Control Group
CPT and Vocabulary Means grouped by Gender

	Males (n = 3)	Females (n = 4)
Pre-CPT	44.00	41.500
Post-CPT	61.333	71.667
Pre-Vocabulary	16.00	14.25
Post-Vocabulary	16.00	17.00

Table 3.17
Experimental Group
CPT and Vocabulary Means grouped by Gender

	Males (n = 5)	Females (n = 6)
Pre-CPT	35.00	37.250
Post-CPT	56.400	61.667
Pre-Vocabulary	15.00	11.933
Post-Vocabulary	8.00 *	15.933 *

Chart 3.17
Experimental Group
Vocabulary Means by Gender



The control group data were examined for differences in scores for the two student types (traditional and non-traditional). T-tests were used to examine differences in the variables post-CPT, post-vocabulary, post-dualism and post-commitment scores. No significant differences were found for post-CPT (t = 0.116, p = 0.915), post-vocabulary (t = -1.651, p = 0.174), post-dualism (t = 0.187, p = 0.864), or post-commitment (t = -1.011, p = 0.358). Table 3.18 contains these data.

Table 3.18
Control Group
T-Test results when grouped by Student Type

	t value	p value
Post-CPT	t = 0.116	p = 0.915
Post-vocabulary	t = -1.651	p = 0.174
Post-Dualism	t = 0.187	p = 0.864
Post-Commitment	t = -1.011	p = 0.358

The experimental group data were examined for differences in scores for the two student types (traditional and non-traditional). T-tests were used to examine differences in the variables post-vocabulary and post-dualism scores. No significant differences were found for post-vocabulary (t = 0.703, p = 0.500) or post-dualism (t = 0.778, p = 0.457). An ANOVA was used for post-CPT and post-commitment in order to account for significant differences in the pre-test scores for these variables. No significant differences were found in the post-CPT scores (F = 0.738, p = 0.415) or the post-commitment scores (F = 3.077, p = 0.110). Table 3.19 contains these data.

Table 3.19
Experimental Group
T-Test or ANOVA results when grouped by Student Type

	t or F ratio	P value
Post-CPT	t = 0.738	P = 0.415
Post-vocabulary	F = 0.703	P = 0.500
Post-Dualism	t = 0.778	P = 0.457
Post-Commitment	F = 3.077	P = 0.110

Data from the two groups were also examined for within group differences on the variable student classification. Due to low numbers in upperclassmen, only the freshmen were compared. T-tests were used to examine differences in the variables CPT, vocabulary, dualism, and commitment scores in the control group by comparing initial and final results. No significant differences were found for CPT (t = -2.016, p = 0.137), vocabulary (t = -0.595, p = 0.578), dualism (t = 0.187, p = 0.859), or commitment (t = 0.860, p = 0.457). Table 3.20 contains these data.

Table 3.20
Control Group
T-Test results for Freshmen

	t value	p value
CPT	t = -2.016	p = 0.137
Vocabulary	t = -0.595	p = 0.578
Dualism	t = 0.187	p = 0.859
Commitment	t = 0.860	p = 0.457

T-tests were used to examine differences in the variables CPT, vocabulary, dualism, and commitment scores in the freshmen in the experimental group by comparing initial and final results. No significant differences were found for commitment (t = 0.320, p = 0.757). However, significant differences were found for CPT (t = -3.264, p = 0.017), vocabulary (t = 6.055, p = 0.001), and dualism (t = -2.380, p = 0.045). Table 3.21 contains these data.

Table 3.21
Experimental Group
T-Test results for Freshmen

	t value	p value
CPT	t = -3.264	p = 0.017 *
Vocabulary	t = 6.055	p = 0.001 *
Dualism	t = -2.380	p = 0.045 *
Commitment	t = 0.320	p = 0.757

The within group analysis found a significant difference in the vocabulary development of males and females in the experimental group. This finding will be explored further when the journals are examined qualitatively. The within group analysis also revealed a significant difference for freshmen in the experimental group for the variables CPT, vocabulary, and dualism. These findings suggest that journal writing does impact the freshmen subgroup differently than other subgroups. Students who were freshmen had an improvement in achievement when they wrote about mathematics. The impact of journal writing on vocabulary development needs to be examined further. It is inconclusive to state whether the significant change in cognitive development had a positive or negative effect on students without future research. Future research conducted over several semesters may confirm that students move deeper into a stage of cognitive development prior to movement beyond the stage. In this case, the result above would show a positive benefit for cognitive development from journal writing. The qualitative analysis may give insight as to why the analyses did not reveal a positive benefit for freshmen in the area of vocabulary development due to the exercise in journal writing. It may also reveal why the students fell deeper into dualism. An investigation will be made into the type of answers the freshmen gave on definition prompts to explore the finding for vocabulary, and an investigation of all prompts will be made to explore the finding for cognitive development. These differences may also need to be further explored in future studies.

Relationship Analysis

To discover any relationships between the variables, correlation coefficients were calculated. A Pearson correlation was calculated to investigate the relationship between vocabulary development and cognitive development. The results suggest there is no relationship between initial or final scores for these variables. These data can be found in Tables 3.22 and 3.23.

Table 3.22
Correlation Coefficients

	Pre-Vocabulary	Pre-Dualism	Pre-Commitment
Control Group			
Pre-Vocabulary	1.000		
Pre-Dualism	0.229	1.000	
Pre-Commitment	-0.395	---	1.000
Experimental Group			
Pre-Vocabulary	1.000		
Pre-Dualism	-0.467	1.000	
Pre-Commitment	0.216	---	1.000

Table 3.23
Correlation Coefficients

	Post-Vocabulary	Post-Dualism	Post-Commitment
Control Group			
Post-Vocabulary	1.000		
Post-Dualism	0.208	1.000	
Post-Commitment	0.292	---	1.000
Experimental Group			
Post-Vocabulary	1.000		
Post-Dualism	-0.062	1.000	
Post-Commitment	0.243	---	1.000

A Pearson correlation was calculated to investigate the relationship between vocabulary development and achievement. The results suggest there is no relationship between initial or final scores for these variables. These data can be found in Tables 3.24 and 3.25.

Table 3.24
Correlation Coefficients

	Pre-Vocabulary	Pre-CPT
Control Group		
Pre-Vocabulary	1.000	
Pre-CPT	0.372	1.000
Experimental Group		
Pre-Vocabulary	1.000	
Pre-CPT	0.567	1.000

Table 3.25
Correlation Coefficients

	Post-Vocabulary	Post-CPT
Control Group		
Post-Vocabulary	1.000	
Post-CPT	0.380	1.000
Experimental Group		
Post-Vocabulary	1.000	
Post-CPT	0.763	1.000

Since the quantitative analysis did not provide evidence of a relationship between vocabulary development and cognitive development or achievement, these relationships will be explored with a qualitative analysis. The qualitative analysis will inspect the students journals to explore the above relationships and further investigate significant changes in pre- and post-test analysis of the variables in this study.

Qualitative Analysis

Students in the experimental group were given an extra assignment for each chapter that involved a journal. The journal was a series of questions to be answered that related to the chapter and addressed vocabulary, language and concept development. These questions are also referred to as prompts. The prompts were of three types: definition (D), conceptual (C), and reflexive (R). The definition prompts addressed vocabulary specific to the chapter. The conceptual prompts asked students to explain a concept or process in their own words. And the reflexive prompts asked students to reflect on the differences in two or more process or the differences in working a specific problem in multiple ways. The journal entries can be seen in Appendix 1. Each entry is recorded as a D, C, or R and the total of each type for each journal is given.

The journals were first evaluated by dividing the prompts according to the above types. Each journal entry in each of the three categories was examined for accuracy. The accuracy was defined as understands, partially understands, or did not understand/did not answer. After all journals were coded, each student was given a percent rating for each type of question at each accuracy level. The percentage was determined by taking the number of question answered at each accuracy level and dividing it by the total number of questions of that type for that specific journal. Rather than looking at a percentage for all six journals, the percentage was calculated by averaging the percentages for two consecutive journals. The percentages were tracked by grouping only two journals in order to note a change in the cognitive level of that student as they progressed in the class. The journals were grouped by two in order to have a larger pool and greater variety of questions for each percentage calculation. If the student increased the percentage in the category understands or partially understands, it might reflect a growth in cognition. The results from the journal examinations can be viewed in Appendix 7.

The journals were also examined to note how the students answered the definition questions, whether they used a book quote or phrased their responses in their own words. The examiner was looking for a possible connection between how they answered these questions and their cognitive development level. The chart in Appendix 8 gives a break down of definition answers. A common note was made from looking at this chart in comparison to the accuracy chart: students who gave book quotes for their definitions did well with the definition type problems. But these students later struggled with the conceptual problems. This may suggest that students were looking for all answers in the book rather than thinking through the questions on their own. It also may implicate the role inner language plays on the construction of meaning by depending on their ability to 'translate' book definitions to their own words in order to make sense of them and use them later when conceptual application is required. Relying on the book for definitions would follow a dualistic stage of development where one would look to an authority for answer rather than within oneself.

Two examples of such finding are cited below. Student 4367 did well on the definition questions, but gave mostly book quotes for the answers. When this student answered the conceptual questions in the same journal (see journals 4& 5, and 6 & 7 in Appendix 7), the answers were incorrect or not answered at all. This leads one to believe that the student was looking for direct answers in the text for conceptual questions just as for definitions. Answers for the conceptual problems were not directly stated in the text and, therefore, had to be thought out by the individual. Student 4367's final cognitive development was scored at the commitment level.

Student 0515 did well on the first and second journals on both the definition and conceptual questions. In these journals, this student phrased answers using wording that was original. However, when student 0515 got to later journals, the success rate was not as good. A notable difference was that the definition questions were now being answered partially with quotes from the book and conceptual questions were being left blank or answered only partially. Student 0515's final cognitive development was scored at the dualism level. There did not seem to be a connection to the way questions were answered and the student's level of cognitive development. Perhaps there was something about these latter assignments that either made the conceptual difficulty more of an issue or the length or timing of the assignment a factor. Some of the prompts in the latter journals asked students to compare concepts from current and past material. The responses should have been an inference based on the students' own experiences rather than something they could find in the book. The demand from other classes or events in the students' life at that time in the semester could also have an impact on the answers given and the time devoted to the journal assignment.

The stage of development that would have been expected in these two cases was the reverse of what was recorded. Answering definition questions from the book only would have been expected by a student in the stage of dualism rather than commitment. And answering questions with ones own wording would follow more of a commitment level of cognitive development.

Journals were also examined for completeness. There seemed to be a connection between completeness and cognitive development. The students were given participation grades for their journals. These grades were calculated by completeness on a scale of one to ten. Although students were not given a lower score for wrong answers, they were marked down for missing answers. A common connection for the students with commitment or relativism as their final cognitive development level was that their journals were more complete. The mean score of these students was 9.55. Those students who were dualistic had a mean score of 9.31 indicating their journals were not as complete. Student 9162 stood out in particular. She was the student who had the most complete journal. She also gave most answers in her own words and completed all questions correctly that asked the student to explore an idea in multiple ways. Although the test manual called for her cognitive development to be lowered due to a high empathy score, her journal entries draw question to that change.

Students 3267 and 5057 show signs of retreat in their stages of cognitive development. Piaget's concept of equilibrium is important to movements between stages. Baxter-Magolda (1988) and Greenes (1995) state that movement between stages may be the result of one's need to adjust his or her way of making meaning to accommodate new experiences. These students who retreated to a former stage may be showing signs of disequilibrium caused by the metacognition and the struggle with meaning that was experienced while journal writing.

Several students, 9162, 9935, 8639, 3267, and 3779 showed a movement deeper into dualism. One explanation could be that the journaling caused disequilibrium in the current stage and the student needed to regain equilibrium in the current stage before they could move between stages or to a higher stage. To explore this notion, this research would need to be repeated and conducted for more than one semester. It would be beneficial to conduct interviews with the students several times during the research to gain additional insight into their cognitive development. Other data that may be of importance is the amount of time spent on each journal, the number of credit hours they were currently taking, and whether this was their first attempt at the class.

By giving responses to individual journals, the researcher was attempting to assist each student in reaching his/her zone of proximal development (ZPD). The researcher would stimulate them to investigate a topic further by encouraging them to expound on their present perspective in a specific way. Comments were given to the students to ask whether the information given by them was complete enough for replication of their idea. Sometimes in mathematics, overlooking the smallest detail like a negative in parenthesis as opposed to outside of them can make a huge difference. If the student overlooked this type of detail, the comment given would ask if there was a difference in stating the response in a slightly different manner. Looking at responses on individual questions from students as a whole prompted the researcher to incorporate different methods of instruction that might be more appropriate to each concept. One example is the question from the chapter six journal on the reduction of a rational expression. It was realized through the students' responses that they were dualistic in this concept. They did not see the connection between factors and exponents that would give them multiple ways to view the simplification. It was realized from this question that the students' dualistic view could also be the result of the dualistic teaching style used by the researcher with respect to this concept. In past semesters, the focus has been only on the exponent rules for simplifying because it was believed by the instructor to be the most direct method. The book instruction had developed this concept in two ways, but the teaching style used in the past only emphasized one. The journal responses gave insight that even more emphasis might be needed for the student to see the concept both ways. Therefore, extra time was taken in the next class period to compare and contrast more examples of simplifying a fraction by using the rules of exponents and then by using a factoring technique. The teaching style needs to focus on both factoring and simplifying by the rules of exponents when introducing this concept, since there may be times when one method lends itself more than the other to a given application.

The percentage assigned to the accuracy level of answers given by each student on journal entries (Appendix 7) was examined. By visual inspection, the female students were constantly answering a higher percentage of questions correctly when compared to the males. In addition, the males evidently did not understand or did not answer the entries a larger percentage of the time when compared to females. To investigate this observed difference, the means for both genders were calculated in the questions subdivisions: definition, conceptual, and reflexive, and answer accuracy level subdivisions: understands and does not understand. The answer accuracy level subdivision, partially understands, was not included. These calculations revealed that the females did have a higher mean percentage for answering the questions correctly for each type of entry and on each chapter. It also revealed that the males had a higher mean percentage for not understanding or not answering the questions for each type of entry and on each chapter except for chapter 4 and 5, definitions. See Table 4.1, 4.2, and 4.3.

Table 4.1
Chapter 1 and 3 Journal Entries
Experimental Group by Gender

		Females	Males
Entry Type	**Categories**	**Means**	**Means**
Definition			
	Understands	83.67	77.63
	Does Not Understand	9.5	13.38
Conceptual			
	Understands	78.92	71.1
	Does Not Understand	8.33	10.5
Reflexive			
	Understands	81.33	60.88
	Does Not Understand	5.833	9.63

Table 4.2
Chapter 4 and 5 Journal Entries
Experimental Group by Gender

		Females	Males
Entry Type	**Categories**	**Means**	**Means**
Definition			
	Understands	75.00	62.75
	Does Not Understand	20.17*	15.63*
Conceptual			
	Understands	58.50	39.38
	Does Not Understand	16.72	31.0
Reflexive			
	Understands	62.75	40.25
	Does Not Understand	23.33	46.75

*exception to percentage comparison noted above.

Table 4.3
Chapter 6 and 7 Journal Entries
Experimental Group by Gender

		Females	Males
Entry Type	**Categories**	**Means**	**Means**
Definition			
	Understands	70.75	68.67
	Does Not Understand	23.42	37.5
Conceptual			
	Understands	54.75	35.67
	Does Not Understand	27.75	52.33
Reflexive			
	Understands	66.25	38.33
	Does Not Understand	28.92	44.17

A t-test for correlated means was calculated to investigate a significant difference between these means. According to the t-tests, the differences were not significant. This information is summarized in Table 4.4, 4.5, and 4.6.

Table 4.4
T-Tests for Chapter 1 and 3 Journal Entries
Experimental Group by Gender

		T-Value	P-Value
Entry Type	**Categories**		
Definition			
	Understands	0.653	0.533
	Does Not Understand	-0.532	0.614
Conceptual			
	Understands	2.064	0.073
	Does Not Understand	-0.360	0.729
Reflexive			
	Understands	1.990	0.084
	Does Not Understand	-0.532	0.609

Table 4.5
T-Tests for Chapter 4 and 5 Journal Entries
Experimental Group by Gender

		T-Value	P-Value
Entry Type	**Categories**		
Definition			
	Understands	0.977	0.378
	Does Not Understand	0.502	0.637
Conceptual			
	Understands	1.290	0.248
	Does Not Understand	-1.238	0.264
Reflexive			
	Understands	1.578	0.200
	Does Not Understand	-1.785	0.165

Table 4.6
T-Tests for Chapter 6 and 7 Journal Entries
Experimental Group by Gender

		T-Value	P-Value
Entry Type	**Categories**		
Definition			
	Understands	0.267	0.797
	Does Not Understand	-0.946	0.421
Conceptual			
	Understands	0.871	0.455
	Does Not Understand	-1.029	0.385
Reflexive			
	Understands	1.128	0.335
	Does Not Understand	-0.513	0.650

Although the differences are not significant. these results along with the review of the journal evaluations suggest that the female students gained more from the journal experience. This would follow Baxter-Magolda's (1988) claim that females are more reflective learners and possibly explain the difference in mean vocabulary scores of the male and female students listed in Table 3.14 and Table 3.15.

The student evaluations of the journaling experience (Appendix 9) were examined to look for recurring themes when questions regarding the completion and value of the journals were answered. Several students (6720, 3779, 5883, 3267, and 4367) commented that the journals were good study tools for the test. Most students agreed that the journals helped them with their mathematics vocabulary. Some students (9162, 6720, and 5883) thought the journals, overlooking the value, were just extra homework. Student 4367 liked the journals and requested that more work of this type be included in the course.

The student evaluations of the journaling experience were also used as a check of final stage of cognitive development. How students responded to the questions on the evaluation gave insight into their cognitive development. There were apparent conflicts between the students' responses and the students' ratings given by the SID-IV. The student responses might show characteristics of one level, yet the SID rated the student at a different level. Student 3267 liked to be able to define things in his own words, yet made reference to the repetition of the journals helping him to memorize. The reference to memorizing is a characteristic of dualism, yet the valuing of the ability to express himself in his own words shows movement out of dualism. The SID-IV rated student 3267 in a final stage of dualism.

Student 3321 was rated by the SID-IV at the commitment stage of cognitive development, yet this student clearly stated that she did not like the fact that answers could not be found in the book. This shows signs of dualism as she was looking to an authority (the text) for the answers rather than searching for them within herself. This student also stated that she did not like to phrase things in her own words, which also shows signs of dualism.

Student 9162 did not like having to write about the problems. She just wanted to work the problems. This also reveals a dualistic trait in that she did not want to do things in multiple ways. This student was rated in a final stage of development of dualism.

Student 5883 commented that answers to the questions were hard to find. This implies that the student was looking for answers in the book as opposed to thinking through the questions to discover the answer on her own. This again reveals dualistic traits. She was rated in a final stage of commitment.

Student 8700 wanted to be able to find answers in the book and also did not like "putting" things in her own words. She was rated by the SID-IV in the final stage of relativism. however. her responses hint toward characteristics of dualism.

It was also noted that a male student. 3267. liked phasing things in his own words. yet a female student. 8700. did not like putting things in her own words. This could be due to the androcentric nature of our language. Since women have been forced to use the language created by men (Code. 1991). they may not be comfortable constructing definitions on their own and may find it difficult to represent their experiences precisely with androcentric language. This emphasizes the need for reflective exercises in the mathematics classroom to assist students. especially the females. in constructing understanding of concepts and relating them to their own experiences.

Validity

Threats to validity for this study are that students could have shown an improvement on the CPT and vocabulary tests simply because they have taken the tests before. Students can guess at responses on the tests. This chance factor can work for or against student scores. Some participants were lost because they dropped the course or were not present on testing dates, thus dropping out of the study. Too many males were dropped from the sample in this process. The researcher did not have control of this situation, but starting with a larger sample would have helped to maintain greater numbers when the sample was split into groups. Frequent absences or lack of participation in all journal entries could also result in low post-test scores. No analyses were completed by looking at the frequency with which students completed journals. Journals were not accepted if they were late, so a student could have completed the journal without having a record of that data for the research. Late journals could not be accepted since they were discussed in class and a student could simply complete the journal during the class discussion. This would not have added insight for the research in regard to the individuals' cognitive or understanding level.

To control for external validity, the same researcher administered the tests. Time limits were not imposed on the vocabulary test or SID. The test environment was the classroom. Cross-instrument contamination was not eliminated because the pre-test instruments were given on the same day. This study cannot be generalized to other beginning algebra students, due to the low numbers in the sample.

CHAPTER V

Summary and Conclusions

Since language is a social construct, defined by the constituents of the community to which it belongs, language may be an environmental factor influencing the learning of mathematics particularly for several student groups including: females and nontraditional students. Language is employed to communicate and is key to the transmission and understanding of information in education. Two nationally recognized mathematics societies, AMATYC and NCTM, acknowledge communication is important to cognitive development. The AMATYC Crossroads (1995) and the NCTM Standards (1998) encourage faculty to adopt instructional strategies that promote the development of both oral and written communication skills. Research cited in the literature review indicated that cognitive development could be accessed through language and enhanced through language development. In mathematics, concepts are often mediated by words because of their inability to be seen or experienced directly. The use of words to build concepts in mathematics provides the rationale for using vocabulary as a means of developing language and discourse in the developmental mathematics classroom.

Feminist theory points out that language is androcentric, since historically women were not in the forefront of formal education. Fennema (1990) suggests that modifying environmental factors that influence gender differences, eg. language, can provide justice and equity in mathematics education.

Nontraditional, adult students have diverse needs in the college classroom. Research suggests that the incorporation of various teaching strategies could be a way of meeting individual needs (Seaman & Fellenz, 1989; Silberman, 1996). Many adults are returning to the educational setting after years since their last exposure to formal mathematics. Since many words in mathematics take on new meaning aside from their everyday uses, nontraditional students may benefit from exercises that focus on mathematics vocabulary. Since nontraditional and female students are characterized as being more reflective learners (Baxter-Magdola, 1987; Cross, 1981), this research incorporated journal writing as a teaching strategy to promote active learning while meeting diverse needs of these two specific groups.

This quasi-experimental study was conducted to gain a better understanding of the role of language and vocabulary development in the mathematics classroom. Through this investigation, connections were made between cognitive development and language that may assist educators in understanding more about student learning.

The review of the literature supported the use of Perry's model to measure the stage of individual cognitive development in developmental mathematics students.

Cognitive development, as outlined in Perry's theory, uses the perception of authority, the approach to knowledge development and the understanding of knowledge as characteristics important to the differentiation between stages. Perry's scheme is very applicable to measuring the cognitive development of college students in the developmental classroom. According to Cameron (1984), students who enter developmental courses are typically in the "dualistic" stage or have typically encountered teaching in dualistic forms. A design was developed using Perry's model and the Scale of Intellectual Development (SID) to measure the stage of cognitive development, the CPT to measure academic achievement and a researcher constructed vocabulary test to measure vocabulary development. The design introduced journal writing as an experimental treatment to promote change in the cognitive development of students enrolled in a developmental algebra course. This chapter summarizes the research results of the analyses of the following: (1) the relationship between learning mathematics vocabulary and cognitive development, (2) the relationship between learning mathematics vocabulary and achievement, (3) the impact of learning mathematics vocabulary for nontraditional, adult learners compared to traditional college-aged students, and (4) the effect of learning mathematics vocabulary through journal writing for male and female students. This chapter also provides limitations of the study and recommendations for future research.

Results of the Study

Students who enrolled in a developmental algebra course in the spring of 2000 were selected as participants for the study. Two classes were used for the study. One was used for control and the other was given an extra assignment of journal writing for each chapter as a treatment for the experiment. The journal was a series of questions to be answered that related to the chapter and addressed vocabulary, language and concept development. These questions are also referred to as prompts. The prompts were of three types: definition, conceptual, and reflexive.

To investigate the relationship between learning mathematics vocabulary (language) and cognitive development, scores were analyzed using the cognitive development test and the vocabulary test. According to the results of the quantitative analyses, no significant results were reported to verify a correlation between cognitive development and language development. However, when the journals and student evaluations of the journals were inspected qualitatively, several relationships were noticed. The journals were first evaluated by dividing the prompts according to types: definition, conceptual, and reflexive. Then responses to the prompts were rated for accuracy. After all journals were coded, each student was given a percent rating for each type of question at each accuracy level. The journals were also examined to note how the students answered the definition questions, whether they used a book quote or phased their responses in their own words. The accuracy of the answers and the type of answers given to different journal prompts were then compared. Students who gave book quotes for their definitions scored high on accuracy for definition type prompts. But these students later struggled with the conceptual problems. This may suggest that students were looking for all answers in the book rather than thinking through the questions on their own. It also may implicate the role inner language plays on the construction of meaning by depending on their ability to 'translate' book definitions to their own words in order to make sense of them and use them later when conceptual application is required. Relying on the book for definitions would follow a dualistic stage of development where one would look to an authority for answer rather than within oneself. Higher accuracy with conceptual and reflective prompts would be characteristic of stages of cognitive development beyond dualism. By looking at individual journals in this manner, there did not seem to be a relationship associated with the cognitive development stage assigned by the SID and vocabulary development.

Journals were also examined for completeness. This examination suggested a connection exists between completeness and cognitive development. A common connection for the students with final cognitive development levels beyond dualism was that their journals were more complete. One student stood out in particular. She was the student who had the most complete journal. She also gave most answers in her own words and completed all questions correctly that asked the student to explore an idea in multiple ways. Although the test manual called for her cognitive development to be lowered due to a high empathy score, her journal entries draw question to that change. In order to investigate these findings further, this research would need to be conducted for more than one semester to see if journals became more complete for other students as they progressed into the stages of development beyond dualism.

To determine whether a relationship existed between learning mathematics vocabulary (language) and achievement, scores were analyzed using the vocabulary test and the CPT. According to the results of the quantitative analysis, there appeared to be no correlation between language development and achievement. The qualitative analyses did not add insight to this relationship.

This research focused on learners of two student types: traditional and nontraditional. Kasworm (1990) defines the traditional student as that person who is 17 – 22 years old, therefore, nontraditional students are those students over the age of 22. These types of students were compared to investigate how learning mathematics vocabulary might impact them differently. An initial comparison was made with means of the vocabulary test that was given during the first week of the class. The means on the vocabulary test for the traditional students in the control and experimental groups were 15 and 14.67 respectively. The means for the nontraditional students in the control and experimental groups were 15 and 16 respectively. These means are comparable to the mean obtained by Miller and Smith (15.0). A lower mean was expected for this study since Miller and Smith (1986) used the vocabulary test for students at the intermediate algebra level, which is the course that follows basic algebra.

After treatment of journal writing was implemented with the experimental group, the two student types were again studied. A post-test was given during the last week of the course. The means on the vocabulary test for the traditional students in the control and experimental groups were 14.33 and 9.11 respectively. The means for the nontraditional students in the control and experimental groups were 18.67 and 7.5 respectively. A t-test was calculated to determine if these differences were significant. Comparing the data for the traditional students in the control and experimental group, no significant differences were found. Significant differences were found for the nontraditional students when the control and experimental groups were compared for the variable, post-vocabulary.

These surprising results suggest that nontraditional students in the control group showed a significantly higher level of vocabulary development without the use of journal writing. This could be attributed to the characteristic of adults as self-directed and independent learners. The control group was instructed to know the vocabulary words listed in the chapter review, but these students were not given a journal to direct their vocabulary development. The nontraditional students in this group may have explored misunderstood concepts in depth until a personal satisfaction was reached, rather than completing a journal to satisfy the teacher's expectations of a grasp of the concept. To explore whether a self-directed method is more effective for certain types of students, further research is needed.

This research also focused on male and female students. Several variables were examined to investigate the effect of learning mathematics vocabulary through journal writing for these students. Initial analyses were performed between male students in the control group and the experimental group as well as between the female students in the control and experimental group. Comparing the data for the male students in the control and experimental group, using a t-test, no significant differences were found between the groups on the variables: pre-CPT, pre-vocabulary, pre-dualism, and pre-commitment.

No significant differences were found between the female students in the control and experimental groups for the variables: pre-CPT, pre-vocabulary, and pre-dualism. There was a significant difference for the females on the variable pre-commitment ($t = 2.664$, $p = 0.029$). This difference may be present due to the average age of the females in the two groups and the probable affect of age on cognitive development. The average age of the females in the control group was 24. For the experimental group females, the average age was 21. These average ages correspond with nontraditional and traditional students respectively. Comparisons were also made between the male and female students in the experimental group. Scores were analyzed using the cognitive development test, the CPT test, and the vocabulary test. Significant differences were only found in the experimental group for the variable vocabulary. Both genders had significant changes in vocabulary scores: 15.00 to 8.00 for males, and 11.93 to 15.93 for females. The journals were inspected qualitatively to further explore this result. One recurring theme was that the female students were more diligent in the completion of their journals. Code might argue that this is a sign that the female gender is more concerned with language since it was originally defined by males. The females may have given more value to the completion of the journal than males, which positively affected their vocabulary scores. As a result, female students may benefit more from spending time on the meaning of words to accommodate for their androcentric nature. This result should be explored with future research.

The journal evaluations completed by students at the conclusion of the study also gave insight into gender differences associated with vocabulary. One male student commented on the value he gave to the ability to define vocabulary in his own words. In comparison, a female student commented that she did not like trying to define words in her own voice. This suggests that females are not comfortable using androcentric language to describe their experiences and therefore have the same difficulty when asked to paraphrase definitions.

To determine if journal writing had an effect on cognitive development, scores were analyzed using the pre- and post-cognitive development scores for each group. The significance found was with the experimental group. They had a significant change in their dualism scores that showed a deeper fall into dualism. By inspecting the journal evaluations, it was apparent that many students still exhibited dualistic characteristics toward learning mathematics regardless of their final rating for cognitive development. Many students relied on book definitions of vocabulary words rather than paraphrasing meanings in their own words. They were not used to talking about mathematics as well as working mathematics problems and showed a dislike for doing both. They showed preference for the traditional method of working problems. This emphasized traits of dualism by wanting to explore a concept in only one way rather than being open to multiple representations of concepts. The lack of movement out of dualism did not give major cause for concern since it has been noted that as part of cognitive development, one may fall deeper into a stage before movement to a higher stage. This can be explained by Piaget's theory of disequilibrium and need to reestablish equilibrium, which is a part of cognitive development. To explore this notion further, future research would need to be conducted over several consecutive semesters using the same sample.

The analysis of the control and experimental groups for within-group differences revealed that freshmen are impacted differently by journal writing than students of other classification levels. Cameron (1984) suggests that most college freshmen are dualistic. Therefore, when examining the data for freshmen within the groups, the focus is also on students who are typically dualistic. The findings from analysis with the control group were not significant on any variables. But the results from the examination of the experimental group variables were significant. The freshmen in the experimental group had a significant change in their dualism scores ($t = -2.380$, $p = 0.045$). They moved deeper into dualism during the research period. These same freshmen also had a significant increase in their achievement ($t = -3.267$, $p = 0.017$). This suggests that the journal writing had a significant effect on this group. The significant change in vocabulary development ($t = 6.055$, $p = 0.001$) for this group needs further exploration. The freshmen in the experimental group had a drastic decline in vocabulary according to the test given. An important element that may have impacted this result is that the authors of the vocabulary test used in this study were not the same as the authors of the textbook used in the course. In reviewing the items on the vocabulary test, it was apparent that the multiple-choice responses from which the students had to choose did not match the definitions that the book used for the same terms. For students at the dualistic stage, this may have caused some confusion. Students who are dualistic may struggle with choosing a definition that is worded differently than a book definition and this might account for the significant decrease in their vocabulary scores.

The journals themselves could have been dualistic, not containing enough open-ended questions and restricting the room that students were given to expound on each topic. The journals were presented on a single sheet of paper and space was left between each prompt for the written responses. None of the students handed in extra papers showing that they needed more space to write on the topics. It was obvious through their crowded writing that they could have used more space at times. When students were given open prompts, for example, "use the space to define any vocabulary words that were new to you in this chapter", the students skipped the prompt. This study might be improved by providing just the prompts and having students use their own paper for their explanations.

Limitations

An obvious limitation of this study was the class sizes. Without larger classes, the potential for type I errors in statistical analysis is increased. Because entire classes were used, it is not clear whether these students are representative of the larger population of students taking college algebra classes so the ability to generalize is limited. Another limitation is the number of classes used. Increasing the classes would help to isolate and evaluate the variables more exactly. Since only one instructor was being used, the influence of teaching style cannot be ruled out as a factor influencing cognitive development. Two instructors would strengthen the argument that journal writing was the true effect that caused a change in cognitive development through language instruction. Controlling for researcher bias towards one group of the other was addressed by using an external auditor. The auditor observed both the experimental and control classes at least twice during the semester to look for inadvertent biases. The observations were conducted on days in which the lesson was rich in vocabulary instruction. No obvious biases were found. Student preference for instructors and consequential impact of the instruction, however, cannot be controlled with only one instructor. Another limitation is that the number of students of male gender was low for this study and could have impacted some results. Low numbers in general impact the power of the statistics. The lower the power, the greater the chance that differences that truly exist will not be detected.

The SID limited the results of the study though its lack of sensitivity. The use of interview with students may have given more insight into changes in cognitive development than a multiple-choice instrument such as the SID. The vocabulary test may have also limited the results of this study because the multiple-choice options for the definition of words on the test did not exactly match definitions given in the book. These limitations provide parameters for future research. Specific findings during the data analysis also gave insight into areas for future research.

Recommendations for Future Research

Future research should be conducted to further explore the relationship between levels of cognitive development and vocabulary development. In this study, students with higher initial levels of cognitive development were more successful with vocabulary development regardless of prescription. Future research should further explore this connection.

This research might have been impacted differently if a different vocabulary test had been used. Since the wording on the vocabulary test did not match the book, the test may have been bias to students in post-dualism levels of cognitive development. A test that more closely resembles the phrasing used by the authors of the book might have provided better results since this sample contains students of different cognitive levels. This research should be repeated with this bias removed.

The SID measures a student's cognitive development for life in general. A test for over-all cognitive development might not have been sensitive enough to measure the changes between cognitive development stages specific to mathematics. A test may be needed to measure cognitive development in one subject area only. Future research should include the development of a test to measure a student's cognitive development in mathematics. A test of this nature might prove to be more sensitive to movement between the stages for cognitive development in mathematics and as a result, be very beneficial for mathematics education research.

The SID also measured cognitive development according to Perry's scheme of development. Since this theory was developed using only male students, it holds a bias to that population. Future research could include the construction of a test to measure cognitive development without a bias toward a specific gender, incorporating both theories of Perry and Belenky mentioned in Chapter 2. Perry's scheme also purposed nine stages of cognitive development. These stages were collapsed into four positions with the SID. Construction of a test that reflects the nine original positions may establish the sensitivity needed to measure small, yet significant changes in early development.

The SID used 115 items to measure the five constructs of cognitive development stages. Future research might do some kind of Delphi or other item analysis to determine which items could be eliminated in order to reduce the test to between five and ten questions per construct. This reduction in questions may make this instrument more suitable for use with developmental students. The SID was created and validated for college freshmen. Although developmental students are college freshman, they have more specialized needs related to testing and reading. Thus, a shorter test would better serve this population.

The nontraditional students in this study appeared to understand key concepts and word meanings through their own directed study. Future research should explore the effect of open-ended journals compared to journals with prompts with this population.

In working with students beyond the level of developmental mathematics, the researcher has noticed the need to expand students' cognitive development beyond dualism. Many times in mathematics a concept is explored in multiple ways. A student who still uses a dualistic perspective may experience frustration with higher-level concepts explored in this manner. This emphasizes the need for further exploration into instructional strategies. which would facilitate cognitive branching into stages beyond dualism.

Chapter VI

Epilogue

Since the conclusion of this research, I have noticed a significant change in my teaching style. This change involves the incorporation of objectives for instruction and learning that facilitate growth in cognitive development. At the beginning of each semester, I now strongly encourage students to explore alternative ways to work mathematics problems. I introduce this idea with the metaphor of going in the back door as opposed to the front door, and by either means arriving at the kitchen table.

I notice that I have used this metaphor quite often as the semesters have progressed since the research. I show alternative methods for problem solving in almost every lesson and I name the methods as the *front door* and *back door* method. Then I usually, jokingly add that the students are also free to *climb in a window*. This last semester, I had students stop me during an example and ask me to go in the back door of the problem rather than proceeding in the direction I was going.

Using this metaphor is a way of communicating that there are alternative methods to work a problem and that the alternative way is the preferred method by some students. One of the largest steps to escaping dualistic thinking that students can make is recognizing multiple ways of problem solving. Students in mathematics often get locked into one method of problem solving and thus adopt a dualistic attitude toward that objective. As instructors, we should model the ability to be open to new ways of working problems.

I have noticed several areas in the discipline of mathematics where dualistic thinking would be a barrier for learning. One such barrier exists in recognizing there can be many forms of the same answer. Most students like to check their answers with the solutions manual. Many times, the answer given in the solutions manual is in a different form than the student's because the method of problem solving chosen to work the problem differed from that of the student. Dualistic students think there is only one correct answer, so they would immediately assume their answer is wrong. If they have been shown alternative methods for solving the problem in class, they may be more likely to accept answers that are simplified to different forms than their own.

In college algebra, one may encounter a system of equations that is dependent, thus having many solutions. In this case, there is a need to express the solutions in parametric form. The process of choosing the variable for the parameter can make the solutions look very different, yet they are the same. Students again need to realize this difference in how the answer looks is due to the ability to express the answer various ways. When solving logarithmic equations, many different approaches can be used to solve the same problem. The solutions to the problem can thus take on many forms as dictated by the process used for problem solving.

In calculus, textbook authors often define the limit definition of the first derivative with three different representations. First, the derivative is defined using the slope of the tangent line using $\lim_{x_1 \to x_0} \frac{f(x_1) - f(x_0)}{x_1 - x_0}$. Then the difference quotient is used, $\lim_{h \to 0} \frac{f(x+h) - f(x)}{h}$. Last, differentials are introduced and the derivative is defined as $\lim_{\Delta x \to 0} \frac{f(x+\Delta x) - f(x)}{\Delta x}$. This shows a textbook example of using multiple representations to define the same concept. In order to follow this explanation, students should be open to understanding ideas in multiple representations. This is best achieved when students are at levels of cognitive development beyond dualism

In trigonometry, the functions, *sin x* and *cos x*, are defined as odd and even functions respectively. This same topic of odd and even functions is also covered in college algebra. Many college algebra students focus on just substituting "-*x*" for *x* to tell if a function is odd or even. By doing this, they learn to watch exponents and make an assumption based on that result: functions with odd powers were odd and functions with even powers were even. I have stressed this relationship in the past, which is not all bad, but what about the connection to the symmetries. I noticed, in fact, that several textbooks define odd and even functions with the variable manipulation and not symmetries. It is important to connect this idea with that of symmetry of the function in order to facilitate a smooth transition for student when they encounter this concept in trigonometry. Most trigonometry texts use the fact that even functions are symmetric to the y-axis and odd functions are symmetric to the origin, since the trigonometric functions do not have different exponents with which to compare. After establishing the relationships of symmetry, the theorems that even functions make f(x) = f(-x) and odd functions make f(-x) = -f(x) are applied. This is the opposite presentation of this concept when compared to what is done in college algebra.

My dissertation study has made a significant difference on how I teach. I tell my students all the time to jump out of dualism. They look at me funny! They constantly show me they are still dualistic. I truly feel that we should aim to elevate our students' levels of cognitive development to increase the likelihood of their success with more advanced mathematics.

As educators, we should take a hard glance at our teaching methods to see if we are perpetuating dualistic thinking through our teaching methodology. We need to be encouraging alternative methods of problem solving through our instruction as well as through our assigned problem sets in order to facilitate cognitive growth.

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Appendix 1

Journal Entries

Chapter 1 Journal

- What is a factor?(D)
- Define the term factorization.(D)
- What is a prime factorization?(D)
- If a number is not prime, then the number is ______________.(D)
- The top number in a fraction is called the ____________.(D)
- The bottom number in a fraction is called the ______________.(D)
- What is the value of a fraction when the numerator and denominator contain the same nonzero number?(C)
- Explain why the denominator of a fraction cannot be zero.(C)
- What value to you give the expression that has a denominator of zero?(C)
- What is an improper fraction?(D)
- Give an example of a mixed numeral?(R)
- Another name for reciprocal is ___________________ (page 21).(C)
- What is a common denominator? When is it necessary?(D)(R)
- What is the absolute value of a number?(D)
- The term rational number is a synonym for ___________.(D)
- What makes two terms like or similar?(C)
- How would you explain to a friend the process of adding and subtracting integers?(C)
- What are three different ways to read –8?(R)
- What are the rules for multiplying and dividing real numbers?(C)
- What acronym helps one remember the order of operations?(R)
- What is a synonym for solution?(D)
- Another name for simplifying fractions is ____________.(D)
- What is the difference in the phrases: 8 less than z and 8 is less than z?(R)

Chapter 3 Journal

- Explain to a classmate how you would graph the point (-2,5).(R)
- When graphing a point, which direction is the x-direction?(C)
  Does the direction change if x is positive or negative?
  Which direction is the y-direction?
  Does the direction change if y is positive or negative? Explain these.(C)
- What are the names of the axes? What directions do each of these go?(D)(C)
- Explain what a solution to an equation is.(C)

- How many points does it take to determine a line?(C)
- To graph a linear equation in two variables:(R)
    1. Find __ solutions (ordered pairs) of the equation.
    2. _________ the solutions as points.
    3. ___________________________ through the points.
    4. Place _____________ on the ends of your graph to show it goes on forever.
- When a line intersects the x-axis, its point of intersection is (__, __).(C)
  This is called the __-intercept.(D)
- When a line intersects the y-axis, its point of intersection is (__, __). (C)
  This is called the __-intercept.(D)
- Explain how you would find these intercepts?(R)
- Why do you only have to use the first quadrant to graph the application problems in section 3.4?(R)
- Explain why the graph of $x = 3$ is a vertical line.(R)
- Describe the graph of $y = -2$.(R)
- Use this space to define any new vocabulary from this chapter.(D)

Chapter 4 Journal

- Write an example that explains the rule for exponents when multiplying.(C)
- Give an example of the Power to Power rule for exponents.(C)
- In your own words describe how you keep the two rules above separate in your mind.(R)
- Construct a polynomial in x(meaning that x is the variable) of degree 5. Make it have four terms with all integer coefficients.(R)
- When you add like terms, you add the ____________, but the variable stays the same.(C)
- Describe one of the processes you could use to multiply binomials.(C)
- Under what conditions will the product of two binomials be a trinomial? a binomial?(R)
- Can you use the FOIL process to multiply two trinomials? Why or Why not?(R)
- Explain the shortcut for squaring a binomial. For example $(x + 3)^2$.c
- What is the degree of a term? What is the degree of a polynomial?(D)(D)
- Why are there two different process for division? Explain when you would use each one.(R)
- What does a negative exponent mean?(C)
- Explain in your own words why 4^0 has to equal 1.(R)

- What is scientific notation? Why is the knowledge of this notation important?(D)(R)
- Explain why $5x^3$ and $(5x)^3$ are not equivalent expressions.(C)
- If two polynomials of n degree are added, is the sum also of n degree? Why or why not?(R)
- When subtracting polynomials, it is imperative that you remove parenthesis first. Why?(C)
- Do -4^2 and $(-4)^2$ both give the value 16 when simplified?(R)

Chapter 5 Journal

- What is a common factor?(D)
- GCF is the abbreviation for ______________________________ ___.(D)
- Describe what happens if you factor 4x rather than the $4x^2$ from $8x^3$-$12x^2$.(R)
- When factoring $x^2 - 5x + 6$, what method would you use?(C)
  What does the last sign tell you?
  What does the middle sign tell you?
- Explain why $2x - 10$ cannot be one of the factors in the correct factorization of $6x^2 - 19x + 10$.(R)
- How do you recognize a perfect square trinomial (or a rabbit)?(R)
- Can both $x^2 - 1$ and $x^2 + 1$ factor?________ Explain.(R)
- Explain the difference in a linear equation and a quadratic equation.(C)
- Do you solve a linear equation different from a quadratic equation?___ ___ Explain.(R)
- The principle of Zero was used to solve quadratic equations. What is the principle of zero?(D)
- What are the factors called in the factorization of the difference of two squares?(D)
- What numbers could be placed in the blank and the trinomial still factor? $X^2 +$ ___$X + 50$?(R)
- Write an outline that you could use for factoring.(C)

Chapter 6 Journal

- What is meant by undefined?(D)
- What is a rational expression? Give an example.(D)(C)
- Explain to a friend how you determine a least common multiple or least common denominator.(C)
- What is a complex fraction?(D)
- What are equivalent fractions? Give an example of a pair of equivalent fractions.(D)(C)
- If it takes 5 hours to complete one job, this could be stated as the rate__ ______

  What does rate mean?(C)(D)

- The expression $\frac{8x^3y^2}{4xy^5}$ can be simplified to $\frac{2x^2}{y^3}$. This can be

accomplished by either using the rules of exponents from chapter 4 or using the elimination of common factors from chapter 6. Show and explain both processes.(C)

Rules of Exponents Elimination of Common Factors

- What process can be used to simplify an equation so it does not contain fractions?(R)
- What is the thing you understand the least about this chapter?
- What if anything about this chapter is frustrating?
- Has this chapter caused you to become better at factoring? Why?

Chapter 7 Journal

- What is the slope of a line?(D)
- Is the graph of x = 3 a horizontal or vertical line? What is unique about all the points on that line?(C)(R)
- Y = mx + b is called the ________________________ form of the equation of the line? Why does it have this name?(D)(R)
- What is the definition of a line?(D)
- What are the steps you would follow to write the equation of the line through (2,5) and (-1,7)? Do not find the line. Just describe the steps.(C)
- What steps do you have to follow to graph the inequality $y \leq x - 5$?(C)
- What is the only difference between the graph of $y < x - 5$ and $y \leq x - 5$?(R)
- State whether each situation is a direct or indirect variation.(C)
    A. A runner's speed in a race and the time it takes to run the race.
    B. The weight of a turkey and the cooking time.
    C. The salary of an employee and the number of hours they work.
- Does the equation y = mx show a direct variation or indirect variation?(D)
- Does the equation $\frac{D}{r} = t$ show a direct variation or an indirect variation?(D)

Between what variable is this relation? What would be viewed as the constant?(C)

Chapter 9 Journal

- What is the difference between a rational and an irrational number?
- Complete the following table of rational and irrational square roots up to 50.

  Rationals   Irrationals
- What is the difference is saying "the square root of 10" and writing it as $\sqrt{10}$?
- Is there a square root for –16?   Why or why not?
- What does the direction "rationalize the denominator" mean?
- To rationalize $\frac{2}{3\sqrt{5}}$ *or* $\frac{2}{3 + \sqrt{5}}$ Do you multiply by the same quantity of one, or is it different?

  What quantity of one would you use? If they should be different, state both.
- Give an example of conjugates.
- Why is it important for the sign within each pair of conjugates to be different?
- If you are solving an equation that contains a square root, what if the first thing you do?
- Why is it important to check your answer if you square both sides of an equation?
- Complete the following table of rationals and irrationals for cube roots up to 64.

  Rational   Irrational
- What does the exponent $\frac{1}{2}$ mean? What does the exponent $\frac{1}{3}$ mean?
- Is there a cube root for –27?

The expression $25^{\frac{3}{2}}$ can be written as $\sqrt{25^3}$ *or* $\left(\sqrt{25}\right)^3$ which one would be better for simplifying?   Why?

Appendix 2

SID IV

Instructions:

This questionnaire lists a series of statements about various topics. Read each statement and decide whether you agree or disagree with each statement as follows:

A - Strongly agree
B - Slightly agree
C - Slightly disagree
D - Strongly disagree

Mark the letter for the choice which best describes your opinion in the blank provided to the left of each question. There are no right or wrong answers so do not spend too much time deciding on a correct answer. Sometimes people try to make themselves out to be better than they are. Therefore, the questionnaire includes some items to check on this. The first thing that comes to mind is probably the best response.

Be sure the number on the answer sheet corresponds to the statement to which you are responding. There is no time limit, but work as quickly as possible.

1. There are some areas in my life where nothing is either right or wrong but rather a matter of my personal preference.
2. I always put forth my best effort.
3. I am always trustworthy and truthful.
4. What happens in my life is always up to me.
5. When all members of a group disagree, it usually means everybody is right.
6. I have often considered how my career will contribute to improving society.
7. The responsibility for my life is my own.
8. The safest decision is no decision at all.
9. I never disagree with other people
10. I always think through problems thoroughly.
11. One thing is certain; Even if there is an absolute truth, men and women will never know about it and therefore, must learn to choose and venture in uncertainty.
12. I have had to set priorities on my activities so that I could achieve a goal.
13. I would not think of marrying a person with religious beliefs different from my own.
14. I prefer that teachers should simply tell me what is important to know.
15. In most situations requiring a decision it is better to listen to someone who knows what they are doing.
16. I am the person that I am because of the choices I have made.
17. Personal values should be adapted to fit the situation.
18. Uncertainty may be the only thing of which a person may be sure about.
19. I schedule activities in my life according to the long-term goals I have set.
20. No moral principle applies to all situations.
21. I often wonder if my career dominates too much of my life.
22. I often consider the potential effects of my behavior on the good of society.
23. I would never date a person of whom my parents would disapprove.
24. I worry that I may become too set in my ways.
25. I never mislead people.
26. My beliefs about current issues are often influenced more by the opinions of other people that by my own ideas.
27. A professor's job is to communicate the facts of his or her field to students.
28. Now that I am fully committed to a career, I plan and think about it often.
29. I considered several fields before choosing my career (major).
30. I base many of my moral decisions on what other people do.

31. When I make a major decision, I often stand back and consider what it is about the choices that appeal to me.
32. With the amount of knowledge greater now than ever before, one cannot feel confident in choosing a singular point of view.
33. I have set priorities on what are the most important goals in my life.
34. The risk of disappointment outweighs commitment to a goal.
35. Once a person decides on an occupation, his or her professional behavior is mostly set.
36. There is nothing more annoying than a question that can have more than one answer.
37. The welfare of other people enters into every decision I make.
38. I frequently think about how I may someday go about rearing my children.
39. I find myself applying skills learned in one field to another area of study.
40. There must be correct answers for the majority of philosophical questions such as, "What is truth?"
41. What other people say is more important than the principle invoked.
42. It is better to simply believe in a religion than to be confused with doubts about it.
43. My life goals are no more specific this year than they were last year.
44. Politicians too often consider societal benefits in the decisions they make.
45. The difficulty of a homework assignment can be judged by the number of pages to be read
46. I am beginning to plan how I can balance other aspects of my life with my career.
47. I have spent a great deal of time thinking about the kind of spouse I would make
48. I have been responsible for supervising the work of others.
49. I have found it is usually better to avoid taking a firm point of view.
50. The true experts in a particular field generally agree with each other.
51. The greatest leaders can show emotions and feelings.
52. A person should not question what the experts believe to be true.
53. Problems and events can only be understood through the eyes of each individual; a common principle can rarely be determined.
54. The value of any behavior depends upon the situation in which it occurs
55. I have assumed the major responsibilities in most areas of my life.
56. I enjoy discussing and studying about social issues of our day
57. I have formulated a personal code of ethics that is not exactly like that of anyone else.
58. Most history professors spend too much class time speculating about theory instead of presenting the facts.
59. It is the job of counselors to guide students into the right occupations.
60. I do not feel ready to firmly support my beliefs.
61. I am free to believe whatever I want only when the experts do not agree.
62. Disagreements regarding important issues should be left to the experts.
63. I would learn more in the humanities if teachers would stick to the facts.
64. Defending one's point of view is unwise, other people's opinions are just as important.
65. People should be made to follow the law exactly and without exception.
66. I have difficulty balancing the needs of others with the needs of myself.
67. Right and wrong never change.
68. The choices I make about my life are always based on my best interests.
69. I am extremely sensitive to the effects I have on others.
70. I have yet to decide what I will do after college.
71. My academic responsibility ends with getting my work done on time.
72. People should obey the police in all situations.
73. A person of good character usually does what he or she is told to do.
74. When I hear an opinion different from mine, I usually ask why the other person believes the way he or she does.
75. A strong person rarely discusses or displays how he or she feels about situations.
76. To a large extent, who I am is defined by the career I have chosen.
77. Every person's opinion should be weighed with equal consideration.
78. I have made a major commitment in at least one area in my life.
79. I need not act upon my beliefs; it is enough that I have them.
80. It is always better to heed the advice of a more experienced person.
81. When presented with a new problem, I seldom anticipate how other people might be affected.

82. I will be able to continually define my job through the ways in which I do my work.
83. If I were having personal problems, I would want a counselor to tell me what to do.
84. I often think, "Whatever I do affects other people."
85. My inner life is very important to me.
86. Issues are so complex today; a person should adopt a single stance only on rare occasions.
87. I can't enjoy the company of people who don't share my moral values.
88. Educators should know by now which is the best teaching method: lecture or small discussion groups.
89. The style with which I carry out my responsibilities is an important part of my identity
90. I have sorted through all my beliefs and decided which ones I will keep and which ones I will discard.
91. All the skills that I learn could be used in both constructive and destructive ways.
92. As I grow older, I should guard against becoming too sensitive about other people.
93. Good teachers never let you leave the classroom with doubts about the subject matter.
94. The best courses emphasize practical rather than theoretical matters.
95. Before I do something new, I usually consider what effect it will have on other people.
96. I have pondered the problems of divorce and considered how I may be able to make my (future) marriage last.
97. I feel contempt for people who have a life philosophy that differs from my own.
98. I do not hesitate to change my opinion when another person presents appropriate evidence.
99. People are not as aware as they should be of their roles.
100. I have difficulty focusing on a single occupational choice.
101. My awareness of my inner resources has not grown during the last Year.
102. I frequently have difficulty accepting the consequences of my decisions.
103. My interpretation of a passage sometimes differs from that of my teachers.
104. I often wonder if I am on the right track.
105. I continually question the reasons why I believe what I do.
106. It is a waste of time to think about how things should be rather than how they are right now.
107. Money spent for welfare in this country should be spent on something else.
108. Circumstances or luck usually determines a person's future.
109. I let others make their own moral decisions instead of telling them what they should do.
110. I am responsible for all of my choices.
111. Almost anything can look fight when viewed from some perspective.
112. I enjoy working with complex ideas.
113. I enjoy problems that do not have a pat answer.
114. No one can be sure about anything anymore.
115. In today's world, a person cannot be certain about choosing any of the options available.

Appendix 3

Mathematics Vocabulary Test

Multiple choice: choose the *best* answer.

1. To *factor* an expression means to
   a. eliminate the exponent by multiplying it out.
   b. write the expression as a multiplication problem.
   c. find a number that will divide into it evenly.
   d. combine like terms.

2. A *rational number.*
   a. contains a radical that cannot be simplified.
   b. contains the imaginary number "i".
   c. is another name for fraction.
   d. is also an integer.

3. The *coefficient* of a term is
   a. the number being multiplied by the variable.
   b. the number being added to the variable.
   c. the exponent of the variable.
   d. the sign of the variable.

4. An *expression*
   a. always contains an equal sign.
   b. always contains an "=" sign or an inequality sign.
   c. never contains an equal sign.
   d. never contains an "=" sign nor an inequality sign.

5. The *index* tells you
   a. how many times to use the base as a factor.
   b. what kind of root to take.
   c. what to divide the radicand by
   d. what power to raise the radicand to.

6. A *rational equation*
   a. always contains a variable in a denominator.
   b. will always have at least one solution.
   c. will always have at least one restricted value.
   d. can always be solved by the cross product rule.

7. To *rationalize a denominator* means to
   a. write the fraction as a decimal.
   b. eliminate the radical from the denominator.
   c. combine like terms in the denominator.
   d. simplify the radical in the denominator.

8. A *complex fraction* is
   a. an imaginary number.
   b. a fraction within a fraction.
   c. a mixed number.
   d. an improper fraction.

9. The *y-intercept* of a graph
   a. is found by letting y = 0, and solving for x.
   b. is the Origin (0,0).
   c. is the place where the graph touches the y-axis.
   d. is the vertex of the parabola.

10. The *perimeter* of a figure is
    a. the amount of space the figure contains.
    b. the number of square unite the figure contains.
    c. the product of all the sides.
    d. the distance around the outside of the figure.

11. The *radicand*
    a. is the exponent of a radical.
    b. tells you what kind of root to take.
    c. tells you what to take the root of.
    d. is divided by the index.

12. The *slope* of a line tells you
    a. its steepness.
    b. its y-intercept.
    c. its run divided by its rise.
    d. its vertex.

13. A *quadratic equation* of a figure
    a. is a second degree polynomial equation.
    b. always has one solution.
    c. always has a fourth degree term in it.
    d. always contains a square root.

14. The *area* of a figure
    a. is the amount of space it contains.
    b. is the number of square feet it contains.
    c. is the distance around the outside of the figure.
    d. is the amount of liquid it holds.

15. If an expression is in *descending order*, the terms are arranged
    a. from highest to lowest coefficient.
    b. from lowest to highest coefficient.
    c. from highest to lowest variable exponent.
    d. from lowest to highest variable exponent.

True - False: mark "1" for true, and "2" for false.

16. The *exponent* tells you how many times to use the base as a factor.

17. To *distribute* means to multiple each term inside the parentheses by whatever is immediately outside and next to the parentheses.

18. The *square root* of a number is the number that when multiplied by two will give you the radicand.

19. *Terms* are separated by "+" or "-" signs which occur outside grouping symbols.

20. An *inequality* must contain one of the following symbols: ">" or "<".

21. The *restricted value* of an equation makes the numerator equal to zero and cannot be used as a solution.

22. A *system of equations* is simply more than one equation.

23. The vertex of a vertical parabola is always the lowest or the highest point of the graph.

24. *Volume* measures the space that a figure contains, and is always expressed in square units.

25. A *radical equation* must contain a variable and a radicand.

26. A *operation* tells you what to do with the terms in an expression.

27. An *equation* has an expression on each side of the equal sign.

28. A *linear equation* is a second degree polynomial equation.

29. The *radius* of a circle is always twice the diameter.

30. The *base* of an exponential expression will be multiplied by itself a certain number of times according to its exponent.

Appendix 4

University of Oklahoma

Subject Consent to Participate in Research

Title of Project: The relationship between language, classroom discourse, cognitive development, achievement, and vocabulary acquisition of developmental mathematics students.

Student Consent Form:

I am a graduate student at the University of Oklahoma, College of Education. I am conducting research on the correlations between math anxiety and math vocabulary as part of my studies in my doctoral program. The purpose of this study is to understand the importance of teaching math vocabulary and journal writing and their effect on anxiety. I would like to invite you to participate in this study.

If you are willing to participate in this study, you will be asked to complete two or three instruments. One is on your knowledge of math vocabulary. The other provides an indication of your level of cognitive development. These instruments will require 45 minutes of your time. To assure anonymity, each participant will be tracked by numbers on the instruments as opposed to your name or ID number. In the case that you do not have a CPT score on file with the assessment office, I will also ask that you take the time to complete that testing as the third instrument.

You are under no obligation to participate. Your willingness to participate or decision to not participate, will not affect your score in this class or any other relations with SWOSU. If you are willing to participate in this study please fill out the attached form which was created to provide additional information about participants.

Name_____________________________ (please print)

age___________ Gender_______________

Type of student: Traditional or Non-traditional
circle one

Number of years since last math class_______

Appendix 5

Heartland University Permission for Research

Date

Dr. Bill Seibert
Chair: Human Subjects Committee
100 Campus Drive
Plains Region State

Dr. Seibert

I request permission to conduct the research for my dissertation on the SWOSU campus with Heartland University students as participants. The project focuses on the role of language in the developmental mathematics classroom. The design of the study is quantitative and involves journal writing to prompts that are provided by the instructor. (see attached copy) I will be using three instruments in my study. They are the CPT, SID-IV and a vocabulary test. I will be following the criteria set forth by The University of Oklahoma's Institutional Review Board (IRB). The study is exempt from review because it does not pose a threat to the well-being of participants. (See attached copy of the IRB form)

I anticipate that data collection will begin in early January and end in late April, early May. I have used these same journal writings as part of my regular courses in the past. I am assured that they do not interfere with course work in any way. If you have any questions or concerns, please contact meat extension 3759.

Thank you.

Rochelle Beatty

Appendix 6

Approval was obtained from the Protection of Human Subjects Committee at Heartland University and the University of Oklahoma Instructional Review Board.

MEMORANDUM

To: Rochelle Beatty
From: Bill Seibert, Chair R.W. Seibert
Protection of Human Subjects Committee
Date: January 14, 2000
Re: Research Proposal

The Protection of Human Subjects Committee (PHSC) has approved, through an expedited review, your research proposal entitled: "Correlation Between Math Vocabulary, Cognitive Development, and Meaning Making of Students Enrolling in the Developmental Math Course, Basic Algebra." This approval is contingent upon the form being amended by adding a line for a parent or legal responsible representative to sign for the under aged participants. The participants are to be given a copy of the consent form. The approval is valid for one year from the date of this letter.

Please provide a copy of the results to the chair of the PHSC upon completion of the research. The copy will serve as your final report and will be stored in the Office of Sponsored Programs archives. Also, for auditing purposes you are required to maintain copies of the informed consent forms for three years.

Enclosed is a stamped copy of your request. Thank you for complying with Protection of Human Subjects regulations.

kab
Enclosure
c: OSP

The University of Oklahoma

OFFICE OF RESEARCH ADMINISTRATION

January 20, 2000

Ms. Rochelle Beatty
117 North Circle
Weatherford OK 73096

Dear Ms. Beatty:

Your research application, "The Relationship Among Language, Classroom Discourse, Cognitive Development, Achievement, and Vocabulary of Developmental Mathematics Students," has been reviewed according to the policies of the Institutional Review Board chaired by Dr. E. Laurette Taylor and found to be exempt from the requirements for full board review. Your project is approved under the regulations of the University of Oklahoma - Norman Campus Policies and Procedures for the Protection of Human Subjects in Research Activities.

Should you wish to deviate from the described protocol, you must notify me and obtain prior approval from the Board for the changes. If the research is to extend beyond 12 months, you must contact this office, in writing, noting any changes or revisions in the protocol and/or informed consent forms, and request an extension of this ruling.

If you have any questions, please contact me.

Sincerely yours,

Susan Wyatt Sedwick, Ph.D.
Administrative Officer
Institutional Review Board

SWS:pw
FY00-142

cc: Dr. E. Laurette Taylor, Chair, Institutional Review Board
Dr. Jayne Fleener, Instructional Leadership & Academic Curriculum

1000 Asp Avenue, Suite 314, Norman, Oklahoma 73019-0430 PHONE: (405) 325-4757 FAX: (405) 325-6029

Appendix 7

Journal Chapter 1 and 3

		Definition			Conceptual			Reflexive		
ID	Student type	U	PU	DNU	U	PU	DNU	U	PU	DNU
9321	Traditional	96	4	0	78	5.5	16.5	65	35	0
5816	Traditional	83.5	4	12.5	91.5	0	8.5	100	0	0
7839	Traditional	75	12.5	12.5	72	19.5	8.5	66.5	25	8.5
9219	Traditional	47	25	28	69.5	5.5	25	56.5	8.5	35
6035	Traditional	92	4	4	74.5	24.5	0	83.5	16.5	0
3802	Non-traditional	100	0	0	80	20	0	83	17	0
1792	Non-traditional	91.5	8.5	0	73	27	0	63.5	26.5	10
7959	Traditional	83.5	4	12.5	80	20	0	100	0	0
6095	Traditional	68	3.5	28.5	64.5	15.5	20	73.5	26.5	0
8240	Traditional	76	11.5	12.5	75	15.5	13.5	40	40	20
1879	Traditional									

U- Understands, PU- Partially Understands, DNU- Does Not Understand

Journal Chapter 4 and 5

		Definition			Conceptual			Reflexive		
ID	Student type	U	PU	DNU	U	PU	DNU	U	PU	DNU
9321	Traditional	87.5	0	12.5	35.5	35.5	29	56	11.5	32.5
5816	Traditional	75	0	25	93	7	0	65.5	4.5	30
7839	Traditional	38.5	25	37.5	14.5	31	54.5	21	13	66
9219	Traditional	50	12.5	37.5	58	36.5	5.5	60	16.5	23.5
6035	Traditional	75	0	25	57.5	35.5	7	69.5	13	17.5
3802	Non-traditional	75	16.5	8.5	64	21.5	14.5	50	31.5	18.5
1792	Non-traditional	75	12.5	12.5	28.5	38	33.5	12.5	17	70.5
7959	Traditional	87.5	0	12.5	43	14.5	42.5	75.5	6.5	18
6095	Traditional	50	50	0	42	29	29	67	0	33
8240	Traditional	87.5	0	12.5	72.5	20.5	7	60.5	22	17.5
1879	Traditional									

U- Understands, PU- Partially Understands, DNU- Does Not Understand

Journal Chapter 6 and 7

		Definition			Conceptual			Reflexive		
ID	Student type	U	PU	DNU	U	PU	DNU	U	PU	DNU
9321	Traditional	80	10	10	50	16.5	33.5	12.5	12.5	75
5816	Traditional	90	0	10	87.5	12.5	0	100	0	0
7839	Traditional	---	---	---	---	---	---	---	---	---
9219	Traditional	50	12.5	37.5	58	36.5	5.5	60	16.5	23.5
6035	Traditional	67.5	12.5	20	26.5	19.5	54	75	0	25
3802	Non-traditional	57	0	43	60	20	20	75	0	25
1792	Non-traditional	60	0	40	7	19.5	73.5	75	12.5	12.5
7959	Traditional	80	0	20	46.5	0	53.5	75	0	25
6095	Traditional	70	0	60	25	0	75	0	0	100
8240	Traditional	76	11.5	12.5	75	16.5	8.5	40	40	20
1879	Traditional									

U- Understands, PU- Partially Understands, DNU- Does Not Understand

Appendix 8

Check for Types of Answers to Definitions

	First Check Types of Answers		
Student ID	Original Wording	Quote from Book	Wrong Answer
9321	7		
5816	5	2	
7839	4	2	1
9219	4	1	2
6035	6		1
3802			
1792	1	5	1
7959	4	2	1
6095	3	3	1
8240	3	4	0
1879			
	Second Check Types of Answers		
Student ID	Original Wording	Quote from Book	Wrong Answer
9321	2	2	1
5816	5	0	0
7839	---	---	---
9219			
6035	2	2	1

3802			
1792	0	4	1
7959	1	3	1
6095	0	2	3
8240	1	3	1

Appendix 9
Journal Evaluation

Have you gained anything from the journal exercises in this class? Please explain.

A. Not Really
B. Yes, I have learned many things from these exercises. I did not complete all of them so I am at a disadvantage, but I did learn.
C. Yes, It has helped me with my math vocabulary.
D. Yes, I have finally started catching on to my vocabulary for algebra.
E. I feel that I have gained a little more vocabulary knowledge from the journal.
F. Without a doubt. I feel that when you write something down, you actually begin to memorize things at a greater advantage.
G. Made me look at questions on what the chapter was about.
H. I thought the homework was just as good or better.
I. A little bit. I can recall a few things that were on the journals.
J. Yes. I learned the vocabulary to a lot of math terms I did not know.

Do you like to compete the journal entries? Why or why not?

A. No, I hated them. They were confusing
B. No they are time consuming and I am lazy.
C. Sometimes, it depends on how much homework I have that day.
D. Honestly no because it is extra work, but I somehow do it anyway.
E. I don't like to complete them because they take too long and it is hard to find the answers to the questions.
F. Yes, it just seems that if you have a good vocabulary in math, it helps you eliminate problems with ease.
G. Yes, made me work at what the chapter was about.
H. No, I didn't like completing them. It just seemed like a lot of extra work. I preferred the homework.
I. Not really, they are kind of hard to find the answers.
J. Most of the times yes, other times it was just more homework to do.

What did you like the most about the journals?

A.
B. The terms.
C. They helped me study for the test.
D. The journal helps me review for the test.
E. I like the fact that they help your grade a little.
F. They way they were written out, it made it easy to look back upon to study for the tests.
G. That they were to the point of the chapter.
H. To work out the problems. Not writing about them.
I. I don't really like the journals.
J. They were good study tools.

What did you like the least about the journals?

A. Too Hard.
B. The numbers
C. Having to do them
D. I did not like receiving grades on them. As I recall, I did get a 3 on one and it was supposed to be for your research.
E. I don't like trying to put the problems in my own words.
F. Nothing, they were fine the way they were presented.
G. Not enough problems.
H. Vocabulary
I. They had too many questions and it took too long to finish them.
J. Just that sometimes they were time consuming.

Did completing the journals help you focus on math vocabulary? Why or why not?

A.
B. Yes, that is the main thing
C. Yes, It helped a lot.
D. Yes, it did.
E. I think it helped me jog my memory from vocabulary that we talked about earlier in the chapter.
F. Yes. Very much so. It provided me with definitions in my own words without having to rely on the book's.
G. Yes, it made you work the problems and get the equation
H. Yes. It made me focus just by constantly asking over and over.
I. Not really. I don't like math very well.
J. yes

What improvements could be made in the journal entries?

A. Do them together in class, so that everyone understands.
B. Nothing except maybe me doing them.
C. Give them to the class at the first of the chapter.
D. They are ok. The only thing is that they are boring.
E. I think the journals could be improved by putting questions that can be found in the book in it. It is sometimes hard to find the answers.
F. Nothing as far as I know
G. More problems and more work on the outside.
H. Leaving them out. I would rather write down definitions on a piece of paper.
I. To not make the questions as hard. Some of the questions were hard to answer.
J. I don't think any improvement is needed.

Student Key

A. 8639	D. 5883	G. 4367	J. 6720
B. 9935	E. 8700	H. 9162	
C. 3779	F. 3267	I. 3312	

Appendix 10
Sample Journal Entry

10

Chapter 5 Journal Name_______________

- What is a common factor? ~~An equivalent expression~~ a factor that divides exactly into every term.
- GCF is the abbreviation for greatest common factor.
- Describe what happens if you factor $4x$ rather than the $4x^2$ from $8x^3-12x^2$.
  An x will still have to be taken out, you will eventually have to do it.
- When factoring x^2-5x+6, what method would you use? regularly factoring a trinomial.

  What does the last sign tell you? The signs will be the same,

  What does the middle sign tell you? That both will be negative.
- Explain why $2x-10$ cannot be one of the factors in the correct factorization of $6x^2-19x+10$.
  The 2 can still be taken out. You don't want common factor.
- Factor the following polynomial by grouping and then by combining like terms.
  $x^2-3x+5x-15$

Grouping	Combining like terms
$(x^2-3x)+(5x-15)$	$x^2+2x-15$
$x(x-3)+5(x-3)$	$(x+5)(x-3)$
$(x+5)(x-3)$	

- Factor the polynomial the way it is written, and then by reordering and factoring out a −1.
  $14+5x-x^2$

As Written	Reordering
	$-1(-x^2+5x+14)$
$(2-x)(7+x)$	$x^2-5x-14$
	$-1(x-7)(x+2)$

- How do you recognize a perfect square trinomial (or a rabbit)?
  It must be a binomial with subtraction in between. this is difference of squares
- Can both x^2-1 and x^2+1 factor? No Explain.
  x^2+1 will not factor because it is not a perfect square.

- Explain the difference in a linear equation and a quadratic equation.

Second degree equations are quadratic. Linear equation is to the 1st degree.

- Do you solve a linear equation different from a quadratic equation? yes Explain.

To solve quadratic equations you use the principle of zero.

- The principle of Zero was used to solve quadratic equations. What is the principle of zero?

If you know the product of 2 numbers is 0, then you can conclude that one or both numbers must be a 0.

- What are the factors called in the factorization of the difference of two squares?

Conjugates

- What numbers could be placed in the blank and the trinomial still factor? $X^2 +$ ____ $X + 50$?

even numbers - numbers that end in zero.

- Write an outline that you could use for factoring.

I. monomials - Always in factoring, factor out GC

A. find two monomials whose product is equivalent to the original monomial.

II. Factoring

A.

III. factoring by grouping can be tried by any polynomial with 4 te