INSTRUCTIONAL STRATEGIES USED BY DEVELOPMENTAL MATHEMATICS INSTRUCTORS IN MISSOURI PUBLIC COMMUNITY COLLEGES TO PROMOTE ACTIVE LEARNING: AN ANALYSIS OF THE COGNITIVE COMPLEXITY

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Doctor of Philosophy

by

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JULY 2015
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INSTRUCTIONAL STRATEGIES USED BY DEVELOPMENTAL MATHEMATICS INSTRUCTORS IN MISSOURI PUBLIC COMMUNITY COLLEGES TO PROMOTE ACTIVE LEARNING: AN ANALYSIS OF THE COGNITIVE COMPLEXITY

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ABSTRACT

This study sought to identify the instructional strategies used by developmental mathematics instructors in Missouri’s public 2-year colleges to engage students in the learning process, determine the cognitive complexity of the instructional strategies, and find out the support needed by these instructors to engage their students in the learning process. A sequential mixed method design was employed in which quantitative and qualitative data was collected. Initial participants in this study included developmental mathematics instructors from all 13 of Missouri’s 2-year public community colleges, making for a total of 494 instructors. Quantitative data statistical analysis was completed on the demographic data, as well as on the rating and implementation of recommended instructional strategies using the Qualtrics survey tool. Qualitative analysis was completed on the instructor descriptions of strategies for engaging students in the learning process. Additionally, three participants were chosen from the survey for case study analysis in which three observations, post-observation interviews, and artifact collections were used to obtain more extensive qualitative data.

Results indicate that developmental mathematics instructors describe the methods they use to engage students in the learning process comparably to those instructional strategies as recommended by the American Mathematical Association of Two-Year Colleges (AMATYC, 2006) to promote active learning, while also including additional strategies. How the instructors rated the instructional strategies as recommended by AMATYC (2006) are given in depth. An overview of the instructional strategies employed by three instructors who were observed, and the cognitive complexity of the tasks and questions used in these instructional strategies is given. Furthermore,
recommendations are given for the support needed by developmental mathematics instructors to aid them in engaging their students in the learning process. Implications are offered for the (1) AMATYC (2006) Framework, (2) Professional development on discovery-based learning, (3) Professional development on cognitive complexity of tasks and questions, and (4) Support needed to implement instructional strategies.
CHAPTER 1: BACKGROUND AND STATEMENT OF THE PROBLEM

Introduction

The benefits of all students having affordable access to quality higher education affect not only the students, but also society (Baum & Ma, 2007). Higher levels of education are associated with an individual’s increase in earnings, resulting in better economic health and spending power, thus benefitting society as a whole. However, many of those who want to attain a post-secondary degree are ill-prepared academically and need remediation in order to have access to higher education and become productive members of society (Cohen, Brawer, & Kisker, 2014). For those students underprepared for college learning, community colleges are the primary destination (Perin, 2013). To help these students become prepared for college-level learning, most community colleges recommend them to enroll in developmental education courses (Boylan, 2002; Perin, 2013).

Developmental education is the field of practice and research in higher education whose theoretical foundation is grounded in developmental psychology and learning theory, and supports the cognitive and affective growth of all postsecondary learners, no matter what level they may be on the learning continuum (Clark-Thayer & Cole, 2009). In addition, developmental education takes a sensitive and reactive approach towards the individual differences and special needs of each learner. Developmental education is based on teaching skills to the learner that they had not been exposed to before and to develop the students’ existing skills further (Neuburger, 1999).

“Recently the state of Missouri, through the Missouri Department of Higher Education, has started to work toward the goal of having 60 percent of state residents
hold some type of postsecondary credential” (Radford, Pearson, Ho, Chambers, & Ferlazzo, 2012, p. 1). To reach this ambitious goal, improvements in postsecondary education must be made in several areas, including developmental education. According to a report commissioned by the Missouri Department of Higher Education (MDHE), along with MPR Associates, Inc., Missouri would be able to graduate a larger number of students more efficiently, “if the state [could] devise and implement programs and policies that…improve the way it is taught” (Radford et al., 2012, p. 1).

**Statement of the Problem**

There is a crisis in our nation’s community colleges as more and more students want to attend community college, but are unprepared for college-level coursework (Stigler, Givvin, & Thompson, 2010). “Between 60 to 70 percent of incoming community college students typically must take at least one developmental mathematics course before they can enroll in college-credit courses” (Strother, Van Campen, & Grunow, 2013, p. 1). Developmental mathematics is defined as mathematics coursework in higher education that is designed to prepare students for entrance into and the study of college-level mathematics (Clark-Thayer & Cole, 2009). The level at which students may begin a developmental mathematics course (prior to a college-level mathematics course) will range from basic arithmetic to any prerequisite course for calculus. The typical sequence of developmental mathematics courses includes basic arithmetic, pre-algebra, elementary algebra, and finally intermediate algebra, all of which must be passed sequentially before the student can enroll in a college-level mathematics course (Stigler et al., 2010).

Most of the students who are placed into developmental mathematics do not succeed in completing the entire sequence of courses prior to college algebra because
they become discouraged and drop out, or because they get weeded out as they fail to pass from one course to the next (Bryk & Treisman, 2010; Stigler et al., 2010; Strother et al., 2013). As a result, developmental mathematics has become a barrier for many students in completing an associate and baccalaureate post-secondary degree, which has significant consequences on their future employment.

Recognizing that many students are coming to postsecondary institutions unprepared for college level mathematics courses, as well as recognizing the disappointing rate of completion of developmental mathematics courses, many states are signing bills into law requiring higher education institutions to take action. In fact, on August 28, 2012, Missouri House Bill 1042 was signed into law, requiring:

all public two-year and four-year higher education institutions to replicate best practices in remediation identified by the coordinating board and institutions from research undertaken by regional educational laboratories, higher education research organizations, and similar organizations with expertise in the subject, and identify and reduce methods that have been found to be ineffective in preparing or retaining students or that delay students from enrollment in college-level courses.

(House Bill No. 1042, 2012, p. 3)

The purpose of this legislation is to ensure that institutions are implementing research-based practices to increase student retention and educational completion in credit-bearing coursework (MDHE, 2013).

In 2012, the Missouri Department of Higher Education (MDHE) initiated an electronic survey to all of Missouri’s institutions of higher education to assess the
condition of developmental education placement, practices, and programs in Missouri (MDHE, 2013). In the survey, institutions were asked to define developmental education and provide a list of best practices used in developmental education. From the results of this survey, the MDHE found institutions have varying definitions of developmental education, “making it difficult to collect data and have effective conversations about this topic” (MDHE, 2013, p. 114). Additionally, with regards to best practices in developmental education, institutions referenced those given in What Works: A Guide to Research-Based Best Practices in Developmental Education (Boylan, 2002), and NADE Self-Evaluation Guides/Best Practice in Academic Support Programs (Clark-Thayer & Cole, 2009). These two publications provide information about best practices to be employed in developmental coursework for professionals invested in improving development education at their institutions at all levels: organizational, administrative, and instructional. These best practices are important because as Boylan (2002) notes, “these practices are typically validated by the research and the literature in developmental education” (p. 3).

As a result of this survey, the Missouri Coordinating Board for Higher Education created their own Principles of Best Practices in Remedial Education (MDHE, 2013, pp. 93–106), which include exploring alternate delivery methods to provide instruction for developmental students. One such alternate instructional method recommended by Boylan (2002) for successful developmental education instruction is the use of active learning techniques or the use of instructional strategies to engage students in the learning process. Likewise, Svinicki and McKeachie (2011) recommend college instructors use
instructional techniques that allow college students to actively engage in the content. (Instructional strategies that promote active learning are defined on page 7.)

**Justification for the Study**

The American Mathematical Association of Two-Year Colleges (AMATYC, 2006) publication *Beyond Crossroads: Implementing Mathematics Standards in the First Two Years of College* recommends that “every teaching activity should promote active learning” (p. 51). Active learning techniques should be implemented, because what we do know is that the traditional, lecture format type of instruction, involving passive learning that is typically provided to developmental mathematics students, did not work for them in their previous schooling, and is still not well suited to their needs (Boylan, 2002; Cox, 2009; Grubb et al., 1999; Perin, 2013). Furthermore, the National Council of Teachers of Mathematics (NCTM) (1991) “indicate that learning occurs as students actively assimilate new information and experiences and construct their own meanings” (p. 2). To aid developmental mathematics instructors in implementing teaching methods that engage students in the learning process, AMATYC (2006) has provided a list of instructional strategies to promote active learning in the developmental mathematics classroom (see Table 1).
Table 1

*Instructional Strategies That Promote Active Learning (AMATYC, 2006, p. 54)*

- **Collaborative/Cooperative Learning.**
  - Provide pairs or small groups of students the opportunity to play a mathematical game, solve a textbook problem, explain, engage in a research project, interpret a graph to another student, review another student’s work, discuss the correct solution, review and critique a video.
  - Assign Internet group projects (in or out of class), technology activities or activities where measurements are taken and analyzed.
  - Facilitate informal study groups outside of class.
  - Ask students to work in pairs on a homework problem before class begins.
  - Provide a location for group review before an upcoming test.

- **Discovery-based Learning.**
  - Use student answers to guide classroom discussion.
  - Present examples that lead to patterns, which form the basis of mathematical rules.
  - Ask students to discover concepts or patterns.

- **Interactive Lecturing and Question-Posing.**
  - Ask students to raise their hand and selecting the 3rd or 4th hand for a response.
  - Ask students to solve a problem and then compare their processes and/or answer with a student nearby.
  - Respond to any answer given (right or wrong) and discuss the logical ramifications of trying to solve the problem using alternative methods.
  - Ask questions to guide students to solutions of problems.
  - Engage students in activities that lead them to develop conceptual understandings.
  - Ask students to write questions that require explanations.

- **Writing.**
  - Ask students to write to an absent student, explaining the most important mathematics concept from the day’s lesson.
  - Ask students at the beginning of the class to write about what they learned from doing the homework.
  - Encourage students to take notes and/or keep track of important mathematics ideas and problem statements by writing a checklist on the board or disseminating a fact sheet.
  - Ask members of a group to describe how to perform mathematical processes integral to the mathematical concept.
  - Include a writing component in homework, student projects, investigation and explorations of mathematical concepts.
When active learning is discussed, both the instructional strategies the teachers use to promote active learning and the strategies the students use to actively engage in the learning process come into play. Thus, the question became, will this research study focus on the instructional strategies used by teachers to help students actively process new information, or will this research study focus on what the students are doing as they actively process new information? Because of the previously stated importance on exploring alternate delivery methods to provide instruction to for developmental students (MDHE, 2013), I chose to focus this research study on the teaching methods used by instructors to promote active learning in their classrooms. Thus, the focus of study was on the instructor, as opposed to the student.

Instructional strategies defined as promoting active learning in mathematics should be centered on “prompt[ing] student interactions and discourse, with the goal of helping students make sense of mathematical concepts and procedures” (NCTM, 2014, p. 10). The teacher’s responsibility is to engage students in mathematical tasks that encourage reasoning and problem solving, as well as enable discourse that will help students work toward a shared understanding of mathematics ideas and concepts. This will enable teachers to allow for opportunities that involve student-student and student-teacher interactions (AMATYC, 2006). Additionally, instructional strategies used should require students to engage in the learning process at a higher-level of cognitive demand, so as to encourage students to use mathematical procedures in ways that are meaningfully connected to mathematical concepts (NCTM, 2014).

For this study I focused specifically on instructional strategies employed in developmental mathematics classrooms in community colleges, because of the lack of
research in this area. According to Perin (2013), there have not been any comprehensive studies that can provide a general statement with respect to the approaches of classroom instruction used in developmental education. Additionally, Grubb et al. (1999) and Mesa, Celis, and Lande (2014) indicate there has been little research evidence on the quality of the mathematics instruction in community colleges.

Finally, I have focused on the cognitive complexity of the tasks and questions used during instruction because research indicates student learning is greatest in those classrooms where the tasks and discourse routinely engage students in higher-level thinking and reasoning (NCTM, 2014). Furthermore, attention to cognitive complexity is important for ensuring that the instruction is aligned with the expectations and assessments of the course (Webb, 2014). The documentation of the cognitive complexity of tasks and questions used is also important to add to the research already conducted by Mesa (2010), in which she found that students were engaged at low levels of cognitive complexity in the developmental mathematics classrooms she studied.

**Rationale for Studying Community Colleges versus Four-Year Institutions**

The majority of jobs today require a high school diploma and some postsecondary education (Carnevale, Smith, & Strohl, 2013). However, many students graduating from high school are not prepared to take college-level credit courses when they enter college (Stigler et al., 2010). In addition, there are major trends occurring in U. S. demographics in concurrence with a greater need for an educated citizenry (Carnevale et al., 2013). As adults respond to increasing or changing job demands, they are returning to college for further education or to prepare for a different occupation, resulting in an increasing population of students entering post-secondary institutions requiring remediation.
According to the researchers Astin (1998), McCabe (2003), and Roueche and Roueche (1999), remediation is not the problem as many have painted it to be, but is the solution to meeting the educational needs of a large number of students in order that they may have access to higher education and become productive members of society. Students who need remediation or who are underprepared when seeking postsecondary education come from multiple societal groups (Oudenhoven, 2002). They include those students who are attending college right out of high school; adult students, who did not start college immediately following high school because they were serving in the military, raising their families, or choosing to work fulltime; and students whose first language is not English.

“One of the key educational tasks that has fallen to community colleges is to offer developmental or remedial education” (Provasnik & Planty, 2008, p. 11). Many 4-year institutions do not believe that teaching remedial courses is their responsibility because they maintain these courses are not college-level, shifting much of the responsibility for remediation to 2-year institutions (Oudenhoven, 2002). According to Cohen et al. (2014), more than half the states have regulations governing remedial instruction, with some states mandating it not be offered in public universities. In other states, limits have been placed on the number of developmental education courses that may be offered by a university, while also directing the universities to arrange developmental coursework for their students within 2-year community colleges. However, in Missouri, where this study was conducted, the Coordinating Board for Higher Education:

will no longer prohibit selective and highly-selective public institutions from offering remedial coursework. This policy does not seek to limit
remediation to a single sector but to work collaboratively to improve student learning outcomes and increase educational attainment.

(CBHE, 2013, p. 3)

Despite this, it is not apparent whether any of these highly-selective public institutions have yet to increase the number of developmental courses they offer to their students.

**Purpose of the Study**

The purpose of this study was to investigate and characterize the instructional strategies used to engage students in the learning process by developmental mathematics instructors in Missouri’s public 2-year colleges. Using an Internet survey, developmental mathematics instructors were asked to describe the instructional strategies they used to engage students in the learning process. Additionally, the instructors were asked to rate the importance of instructional strategies that can be used to promote active learning as recommended by AMATYC (2006) and whether they had already implemented or intended to implement any of these strategies. Another purpose of this study was to analyze the cognitive levels of the mathematics tasks and questions that developmental mathematics instructors were implementing in their instructional strategies. Determining the level of cognitive complexity of the tasks and questions used in the instructional strategies was fundamental, because research indicates student learning is greatest in those classrooms where the tasks and discourse routinely engage students in high-level thinking and reasoning (NCTM, 2014; Stein & Lane, 1996; Weiss & Pasley, 2004).

Finally, this study investigated whether instructors felt they needed professional development to aid in the implementation of instructional strategies to engage students in the learning process. It was important to inquire if instructors feel the need for
professional development, since few of the instructors teaching developmental education courses have been specifically trained to teach developmental students or even college students (Smittle, 2003). As a result, there may be a potential need for developmental mathematics instructors to participate in professional development to allow them to more effectively teach developmental mathematics students (Perin, 2013).

**Theoretical Framework**

The National Council of Teachers of Mathematics (NCTM) (1991) “indicate that learning occurs as students actively assimilate new information and experiences and construct their own meanings” (p. 2). The research-based framework of instructional strategies to promote active learning in developmental mathematics as recommended by AMATYC (2006), provides the foundation for the survey and observation protocols for this study (see Table 1).

In order to assess the quality of mathematics instruction it is necessary to attend to the cognitive complexity of the tasks implemented as well as the nature of the instructor’s questions (Mesa et al., 2014). In this study, *The Task Analysis Guide* created by Smith and Stein (1998, p. 348) will be utilized to categorize mathematical tasks from lower-level demands to higher-level demands, in order to determine the cognitive complexity of the tasks (see Table 2). The questions posed during the instructional strategies used to promote active learning will be analyzed using a taxonomy that I created, *Framework for Determining Cognitive Level of the Types of Questions Used in Mathematics Teaching* (see Table 3), by merging the Framework for the Types of Questions used in Mathematics Teaching as recommended by NCTM (2014) in *Principles to Actions:*
Ensuring Mathematical Success for All (pp. 36–37) with the cognitive dimension of the revised version of Blooms’ Taxonomy by Anderson and Krathwohl (2001).

The instructional strategies used to engage students in the learning process that I explored in this research study were those that allowed students the best opportunity to learn mathematics in developmental mathematics classrooms. According to Hiebert and Grouws (2007) and the National Research Council (NRC, 2001), the opportunity to learn is the single most important factor predicting student success. What influences the opportunity to learn is the types of tasks teachers’ introduce, the types of questions they use and answers they accept, and finally the kind of discussions they lead in their classes (Hiebert & Grouws, 2007; Stein, Remillard, & Smith, 2007). Teachers who work toward giving all students the opportunity to learn in their classrooms are those who put forth the effort to create situations that allow students to actively engage in high-level tasks and discourse.
Table 2

Task Analysis Guide – Levels of Cognitive Demand

<table>
<thead>
<tr>
<th>Lower Level Demand</th>
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<tr>
<td>Memorization Tasks – Coded L1</td>
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<tr>
<td>➢ Involve either reproducing previously learned facts, rules, formulae, or definitions OR committing facts, rules, formulae, or definitions to memory.</td>
<td></td>
</tr>
<tr>
<td>➢ Cannot be solved using procedures because a procedure does not exist or because the time frame in which the task is being completed is too short to use a procedure.</td>
<td></td>
</tr>
<tr>
<td>➢ Are not ambiguous—such tasks involve exact reproduction of previously seen material and what is to be reproduced is clearly and directly stated.</td>
<td></td>
</tr>
<tr>
<td>➢ Have no connection to the concepts or meaning that underlie the facts, rules, formulae, or definitions being learned or reproduced.</td>
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| Procedures without Connections Tasks – Coded L2 |  |
| ➢ Are algorithmic. Use of the procedure is either specifically called for or its use is evident based on prior instruction, experience, or placement of task. |  |
| ➢ Require limited cognitive demand for successful completion. There is little ambiguity about what needs to be done and how to do it. |  |
| ➢ Have no connection to the concepts or meaning that underlie the procedure being used. |  |
| ➢ Are focused on producing correct answers rather than developing mathematical understanding. |  |
| ➢ Require no explanations, or explanations that focus solely on describing the procedure that was used. |  |

<table>
<thead>
<tr>
<th>Higher Level Demand</th>
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<tr>
<td>Procedures with Connections Tasks – Coded L3</td>
<td></td>
</tr>
<tr>
<td>➢ Focus students’ attention on the use of procedures for the purpose of developing deeper levels of understanding of mathematical concepts and ideas.</td>
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</tr>
<tr>
<td>➢ Suggest pathways to follow that are broad general procedures that have close connections to underlying conceptual ideas as opposed to narrow algorithms that are opaque with respect to underlying concepts.</td>
<td></td>
</tr>
<tr>
<td>➢ Usually are represented in multiple ways. Making connections among multiple representations helps to develop meaning.</td>
<td></td>
</tr>
<tr>
<td>➢ Require some degree of cognitive effort. Although general procedures may be followed, they cannot be followed mindlessly. Students need to engage with the conceptual ideas that underlie the procedures in order to successfully complete the task and develop understanding.</td>
<td></td>
</tr>
</tbody>
</table>

| Doing Mathematics Tasks – Coded L4 |  |
| ➢ Require complex and nonalgorithmic thinking (i.e., there is not a predictable, well-rehearsed approach or pathway explicitly suggested by the task, task instructions, or a worked-out example). |  |
| ➢ Require students to explore and understand the nature of mathematical concepts, processes, or relationships. |  |
| ➢ Demand self-monitoring or self-regulation of one’s own cognitive processes. |  |
| ➢ Require students to access relevant knowledge and experiences and make appropriate use of them in working through the task. |  |
| ➢ Require students to analyze the task and actively examine task constraints that may limit possible solution strategies and solutions. |  |
| ➢ Require considerable cognitive effort and may involve some level of anxiety for the student due to the unpredictable nature of the solution process required. |  |
Table 3

Framework for Determining Cognitive Level of the Types of Questions Used in Mathematics Teaching

<table>
<thead>
<tr>
<th>Question Type and Knowledge Gained</th>
<th>Revised Bloom’s Taxonomy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The Cognitive Process Dimension</td>
</tr>
<tr>
<td></td>
<td>1. Remember (Knowledge)</td>
</tr>
<tr>
<td></td>
<td>2. Understand (Comprehension)</td>
</tr>
<tr>
<td></td>
<td>3. Apply (Application)</td>
</tr>
<tr>
<td></td>
<td>4. Analyze (Analysis)</td>
</tr>
<tr>
<td></td>
<td>5. Evaluate (Evaluation)</td>
</tr>
<tr>
<td></td>
<td>6. Create (Synthesis)</td>
</tr>
</tbody>
</table>

| 1. Gathering Information – Factual Knowledge | 1.1.A Recognizing |
|                                           | 1.1.B Retrieving |
|                                           | Coded Q1.1 |

| 2. Probing Thinking – Procedural Knowledge | 2.2.A Interpreting |
|                                           | 2.2.B Exemplifying |
|                                           | 2.2.C Classifying |
|                                           | 2.2.D Summarizing |
|                                           | 2.2.E Inferring |
|                                           | 2.2.F Comparing |
|                                           | 2.2.G Explaining |
|                                           | Coded Q2.2 |

| 3. Making Mathematics Visible – Conceptual Knowledge | 3.3 Implementing |
|                                                    | Coded Q3.3 |

| 4. Encouraging Reflection & Justification – Meta-Cognitive Knowledge | 4.4 Attributing |
|                                                                    | Coded Q4.4 |

| | 4.3.A Differentiating |
| | 4.3.B Organizing |
| | 5.3 Checking |
| | Coded Q3.2 |
| | Coded Q4.3 |
| | Coded Q5.3 |
| | 5.4 Critiquing |
| | Coded Q4.4 |
| | Coded Q5.4 |
| | Coded Q6.4 |
Research Questions

In order to investigate and characterize the instructional strategies used by developmental mathematics instructors in Missouri’s public 2-year colleges to engage students in the learning process, determine the cognitive complexity of the instructional strategies, and find out the support needed by these instructors to engage their students in the learning process, the following research questions were asked:

1. How do Missouri community college developmental mathematics instructors describe the instructional strategies they use to promote active learning?

2. What instructional strategies used to promote active learning, as recommended by the American Mathematical Association of Two-Year Colleges (AMATYC), do developmental mathematics instructors rate as important and indicate they employ in their classrooms?

3. What is the cognitive complexity of the mathematical tasks and questions employed by the instructors during the instructional strategies?

4. What types of professional development do Missouri community college developmental mathematics instructors indicate is needed in order to successfully implement instructional strategies to promote active learning in their instruction?

The information resulting from these questions should allow us to become more knowledgeable about the instructional strategies that developmental mathematics instructors believe are most effective in engaging developmental mathematics students in the learning process, as well as learn about the types of instructional strategies that are actually being used in the classroom. Additionally, the analysis of the cognitive complexity of the tasks and questions will portray the depth of the mathematical thinking...
that the developmental mathematics instructors are attempting to engage the students in. The instructors may find this interesting to see where their questions and tasks fall on a matrix such as the one in Table 3, as they seek to engage their students in more rigorous mathematical thinking. Finally, from this study we will learn from the instructors what they believe to be most beneficial in supporting them as they attempt to use instructional strategies that promote active learning to engage their students in the learning process.

**Organization of This Dissertation**

The pages that follow are organized in such a way as to provide the reader a rationale for the study through the use of the literature review, the methods used to carry out the study, the results of the study, and the possible implications for the field. Chapter 2 provides a literature review for the study. In Chapter 3, I explain the methodology used, including the processes of data collection and analyses used. Chapter 4 contains the results and analysis of the data collected during this study. Finally, in Chapter 5, I discuss key findings, implications, and suggest future research.
CHAPTER 2: REVIEW OF THE LITERATURE

Who is Responsible for Teaching the Academically Underprepared?

The 21st century requires American citizens to be prepared for the information-age; therefore, those involved in educational policy must find a way to make postsecondary education more accessible for all (McCabe, 2000). If quality college programs are to be maintained, then remedial services must be provided, for access and remedial education are intertwined. By 2050, there will be a profound change in our nation’s portrait, in that “the United States will be almost a ‘majority minority’ country” (McCabe, 2000, p. 9). Approximately 53% of the population will be non-Hispanic white, as opposed to today’s 75%. With respect to America’s youth, the shift will be even more dramatic with half of the population being a minority before the year 2020. This is a problem because although minorities have made progress educationally, they are still far from achieving the educational equity of non-minorities.

Besides ethnicity, the aging of our population is also at work in changing our nation’s demographics (McCabe, 2000). The baby boomer generation is beginning to retire, influencing the future of the nation by the sheer lost of their numbers in the workplace. As the workforce shrinks, it will be up to our education system to ensure that there will be enough Americans prepared for employment. Our youth must gain the high competencies needed for employment in the information-age. As we approach the 21st century, the importance of an advanced education has become more apparent (Carnevale et al., 2013; McCabe, 2000). Workers will need to have higher-order information competencies as their base. Together, education and technology will increase individual productivity, creating higher wages and helping the U.S. to preserve its global
competitiveness. By 2020, 65% of all jobs will require some postsecondary education, which is up from 59% in 2010 (Carnevale et al., 2013). Meeting this number may be a challenge, because approximately 59% of students graduating from high school will enter postsecondary education, with only 42% of those students truly being prepared for college work (McCabe, 2000). Remedial education must be accessible throughout postsecondary education, due to the large numbers of people reaching adulthood without the necessary skills for employment in the information age.

The question becomes, who is responsible for providing remedial education in higher education, 2-year or 4-year institutions? Many 4-year institutions do not believe that teaching remedial courses is their responsibility because they maintain these courses are not college-level, resulting in shifting much of the responsibility for remediation to 2-year institutions (Oudenhoven, 2002). All 2-year public institutions must offer remedial courses (Cohen et al., 2014), which has allowed community colleges to become an important and integral part of postsecondary education (Boswell & Wilson, 2004). No other sector of America’s public higher education has matched the growth of community colleges, verifying the rising importance of public 2-year colleges.

**Importance of Community Colleges to Developmental Education**

**The Mission of Community Colleges**

Community colleges are indeed American because they truly represent the United States at its best (Cohen et al., 2014). In order to meet society’s needs they are constantly trying new approaches to battle longstanding problems. Community colleges are known for having an open door policy for individuals, in order to improve social mobility that has long been characterized as an American trait. The concept of the open door represents
the belief that education is necessary for upholding democracy, is necessary for the improvement of society, and works to improve the opportunity of postsecondary education for all people (Roueche & Roueche, 1999).

The expression “open door” is unique to community colleges and brings with it some serious misconceptions about what exactly it means for students (Roueche & Roueche, 1999). Open door does not mean students can enroll in just any program area, but means that students have access to instruction from which they can benefit. Their choices for coursework are limited only by their academic abilities and mastered prerequisites. “Community colleges are obligated on principle and funded by law to match the abilities of under-prepared students in their curriculum and instruction, and to give those students true access to higher education” (Roueche & Roueche, 1999, p. 8). Because 42% of community college first year students enroll in at least one developmental education course, the open door policy is shown to fulfill a very real need for educational access (Boswell & Wilson, 2004).

The mission of the community college has been “an historically contingent social and educational process that is structured by the needs of local communities, students demands, and regional and national imperatives for economic and workforce development” (Meier, 2013, p. 5). During the period of the Great Depression, the economic and social crisis caused the renaming and redefinition of the junior college to become the community college, as the needs of the community because the primary focus (Meier, 2013). By the 1960s, factors such as the G.I. Bill, baby boom demographics, and economic development, as well as the call for equality for those who had been previously excluded from higher education, helped to establish the community college as a
postsecondary educational institution (McCabe, 2000; Meier, 2013). As a result of providing access to students with a broader range of academic abilities, remedial education programs were created. Consequently, as dissatisfaction with K–12 public education grew in the 1980s and 1990s, many legislators regarded remedial education as a duplication of expenditures on high school education, while also reducing college standards.

On a positive note, developmental education should be “defined as a ‘core function’ of colleges and the bridge between access to higher education and the reality of that opportunity” (Neuburger, 1999, p. 9). Developmental education is cost-effective, because without it academically unprepared students would be unable to enter postsecondary education, leaving them to compete for unskilled jobs or become dependent on the government, which are much more expensive options. Thus, developmental education is essential to our nation’s well being (McCabe, 2003). No other educational program is as underappreciated, seeing that both legislatures and colleges give it low priority. It is important that we get beyond blaming the victim (students) and the arguments about the duplication of expenditures to educate the same students twice, and understand that remediation is an important component of higher education. In fact, “developmental education is one of the most important programs community colleges offer” (McCabe, 2003, p. 17).

**Characteristics of Developmental Education Students**

In order to be prepared to teach and serve developmental education students, it is important to know the demographics of the students enrolling in these courses. Nationally, at least one remedial course is taken by nearly half of all first-time
postsecondary students (Radford et al., 2012). Between developmental reading, writing, and mathematics, mathematics is the most common subject in which students enrolled. According to Radford et al. (2012), remedial course taking varied between 2-year and 4-year institutions. Close to two-thirds of Missouri’s public 2-year college students enrolled in some type of remedial course, while the percentage was approximately one-fifth at Missouri’s public four-year institutions. This is due in part to how 2-year and 4-year institutions vary in the students they serve and in their admissions requirements. Additionally, Radford et al. (2012), indicates that nationally as well as in Missouri, students with certain race/ethnic characteristics are more likely to participate in remedial education (bolded entries in Table 4). These same groups of students are also more likely to participate in mathematics remediation.

Table 4

Percentage of National and Missouri First-Time Undergraduates Participating in Remedial Education by Race/Ethnicity (Radford et al., 2012, p. 5)

<table>
<thead>
<tr>
<th></th>
<th>National (2003-04 cohort)*</th>
<th>Missouri (fall 2011 cohort)*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Any</td>
<td>Math</td>
</tr>
<tr>
<td>White</td>
<td>46.0</td>
<td>39.4</td>
</tr>
<tr>
<td>Black</td>
<td><strong>60.2</strong></td>
<td><strong>51.6</strong></td>
</tr>
<tr>
<td>Hispanic</td>
<td><strong>61.5</strong></td>
<td><strong>49.5</strong></td>
</tr>
<tr>
<td>Asian</td>
<td>46.7</td>
<td>31.2</td>
</tr>
</tbody>
</table>

With respect to enrollment at 2-year colleges, the percentage of women is higher at 61%, than with men at 39% (AACC, 2015). The percentage of students attending part-time is at 59%, with 41% attending full-time. The national average age of the 2-year college student is 29, signifying 2-year colleges are serving both traditional and non-traditional students (AACC, 2014; Cohen et al., 2014). However, with the median age at 22 and mode at just under age 19, there is a inconsistency among the three measures (Cohen et al., 2014). The median age is at 22, representing those students who either delayed beginning college after finishing high school or entered community college after dropping out of another institution. The mode is age19, reflecting the greatest number of students, who are those starting straight out of high school. Thus, a graph representing the age of community college students would actually show a swell at the low end of the scale, a peak at age 19, and a long tail toward the high end. The number of nontraditional students would be minimal in this depiction.

Students who need remediation or who are underprepared when seeking postsecondary education come from multiple societal groups (Oudenhoven, 2002). They include those students who are the traditional-age or those attending college right out of high school, who may not have learned the information the first time around. They are also adult students who are the non-traditional age, who did not start college immediately following high school, or who are now pursuing postsecondary education to pursue a new career goal, or are attending school because they finally have time. Finally, they include those students whose first language is not English.

Instructors in Community College’s Developmental Mathematics
Most 2-year and 4-year colleges report their remedial education courses are taught by either full-time or part-time instructors, with many more part-time instructors as a whole (Roueche & Roueche, 1999). According to Roueche and Roueche (1999), “National survey data suggest that far more part-time than full-time faculty are hired to teach remedial and developmental courses than to teach any other programs or courses” (p. 26). Additionally, many of those teaching developmental mathematics courses have had little or no specific training in this field (McCabe, 2003). There are very few teacher education programs that provide preparation for developmental education instruction (Perin, 2013). What makes teaching these students even more difficult is that for many instructors, the knowledge they gained about teaching while in their graduate programs is significantly different than the knowledge they need to teach developmental education classes. Perin (2013), states that in studies of students in developmental classes, these students have high levels of anxiety towards the subject matter, must overcome memories of academic failure, and perceive “instructors hold low expectations based on race- or gender-based stereotypical preconceptions” (p. 91). All of these factors can serve to be a challenge when teaching developmental education classes.

McCabe (2003) argues that, whenever possible, institutions should hire instructors who have expressed an interest in working with underprepared students. In order to succeed, developmental mathematics students need more than the content of the mathematics courses, they also need personal support (McCabe, 2000). For the institution and instructors to provide personal support, more resources are needed. However, securing adequate financial support of remedial courses is difficult. Students completing remedial courses have delayed time to graduation. These students also have lower
graduation rates. Lower graduation rates and increased time to degree of students who do complete their degree impacts the overall student success rates for the institution. Lower student success rates can impact performance funding support available to public institutions of higher education.

On a positive note, Cohen et al. (2014) notes that as developmental education has grown, separate divisions, including faculty members, support staff, and counselors, have been formed at 2-year colleges to accommodate these students. This has led to an increased level of professional appreciation among developmental educators. For instructors of developmental mathematics there are many professional education organizations, such as the American Mathematical Association of Two-Year Colleges (AMATYC), Missouri Mathematical Association of Two-Year Colleges (MOMATYC), the National Association of Developmental Educators (NADE), and Missouri Developmental Education Consortium (MO-DEC), to name a few. These organizations all work to support those who are educating developmental students.

Developmental Mathematics Pedagogy

Community colleges are considered teaching institutions; hence community college instructors focus the majority of their attention to the instructional process without devoting much time to research (Cohen et al., 2014). In addition, because many community colleges do not conduct extensive institutional research, there is little information on the effectiveness of utilizing different types of teaching approaches (Grubb et al., 1999). Unfortunately, many community colleges fail to investigate the growing research regarding successful developmental mathematics instruction (McCabe, 2000). This lack of priority with respect to research leads to instructional practices that
are outdated, inexpensive, and easy to implement. However, Cohen et al. (2014) argues that part of the lack of knowledge of the latest research may have to do with the continuing problem that a large number of developmental instructors are part-timers.

In many community colleges today, traditional classroom instruction still dominates, meaning students are still learning by sitting and listening to lectures, watching teacher demonstrations, reading books, and completing examinations (Cohen et al., 2014; Grubb et al., 1999). On a positive note, the traditional approach could be considered efficient because it fulfills the instructors’ responsibility, in that the material is presented to the students and the students are assessed using proficiency tests covering the content presented during class (Mesa et al., 2014). Consequently, when instructors utilize an instructional approach that does not include the traditional lecture, many students feel that their instructor have not done a good job teaching them, because they are not accustomed to this style of instruction and/or are not expecting to experience this type of instruction in a college classroom (Cox, 2009).

In higher education, students have a perception of teaching that oppose instructors’ use of alternate forms of teaching besides the traditional lecture (Cox, 2009). These expectations held by students undermine instructors’ efforts to achieve their pedagogical goals when they attempt alternate forms of teaching. Cox (2009) found that when instructors did use alternate forms of teaching, the pedagogical conceptions held by students led to overt resistance and prevented them from benefiting from these instructional approaches, which they perceived as a waste of time or as a lack of instruction. Thus, she found that utilizing alternate instructional approaches “challenged students’ expectations and institutionally embedded norms simultaneously” (p. 96).
Students’ ideas of learning consist of recording information found in textbooks and lectures, and repeating this information on a test. When the traditional model of instruction is not used, students often respond with skepticism and/or disrespect.

What we do know is that the traditional, lecture format type of instruction typically provided to developmental mathematics students did not work for them in their previous schooling, and is still not well suited to their needs (Boylan, 2002; Cox, 2009; Grubb et al., 1999; Perin, 2013). This type of instruction typically involves passive learning, in which the students attempt to absorb the knowledge conveyed by the teacher (Grubb et al., 1999). In this situation, students’ aspire to high test performance as opposed to learning. This conventional approach to teaching tends to represent several assumptions about intelligence: “that it is relatively fixed as rather than malleable, and that it is single-dimensioned rather than multiple-dimensioned” (Grubb et al., 1999, p. 31). The idea that intelligence is fixed leads to an emphasis on screening students with the purpose of tracking students based on their assessed abilities. Thus, the students who score poorly on diagnostic assessments are considered deficient in the required skills. “The language of deficiency is quite common in conventional instruction, particularly in remedial or developmental education” (Grubb et al., 1999, p. 31).

An alternate instructional approach, is one that is more meaning-centered, where the central focus is to allow students to create the meaning of the learning for themselves, which is more promising for higher transfer and motivation (Grubb et al., 1999). According to Grubb et al. (1999) this is referred to as instruction that encourages active learning, because the instructor is more of a guide for the students as she/he tailors tasks and questions in ways that allows students to create their own knowledge. Implementing
a student-centered approach such as this, calls for students to be actively engaged in their learning. In order for instructors to shift their classroom teaching practices from a traditional approach to a more student-centered approach, teachers must see their students as learners who are actively engaged in the problem-solving process rather than being empty vessels for them to fill (Akkus & Hand, 2011).

Instructors who are implementing strategies to promote active learning must structure and lead the tasks for developmental students, while at the same time teaching them to become autonomous thinkers (Smittle, 2003). According to Smittle (2003), it is important that those instructors committed to working with developmental students focus on developing both their cognitive and non-cognitive needs when implementing instructional strategies. This involves providing frequent feedback to students and helping these students interpret the feedback because they lack ability to judge their progress from assessments. Additionally, this includes motivating students to learn and participate in learning activities, which requires teaching students skills for self-regulation. What is important to note, is that as instructors implement instructional strategies that support active learning, this also allows instructors to develop students’ metacognitive skills, which is very important for developmental education students (NRC, 2000; Smittle, 2003).

**Instructional Strategies to Promote Active Learning**

**Importance of Promoting Active Learning in Developmental Education**

In the book, *What Works: Research-Based Best Practices in Developmental Education* by Boylan (2002), an extensive list of best practices for use in developmental education is given. The information in this book was gathered through a collaborative
study between the National Center for Developmental Education (NCDE) and the Continuous Quality Improvement Network (CQIN). In addition, the American Productivity and Quality Center (APQC) of Houston, Texas was chosen to partner with CQIN because they specialized in benchmarking research. The NCDE agreed to combine their findings with the CQIN/APQC benchmark study to generate a volume that described research-based best practices employed in developmental education. This study began in 1999 and continued through 2000. From this study, Boylan (2002) found that best practices employed by highly successful developmental programs consist of: organizational, administrative, instructional, counseling, advising, and tutoring activities. My research study has focused on the best practices recommended for instruction.

Reports from institutions having successful developmental education programs frequently cite the use of implementing instruction to promote active learning as a major factor in their accomplishment (Boylan, 2002; Perin, 2013). “If there is one thing that literature agrees on universally, it is the value of involving the learner in the active processing of incoming information” (Svinicki & McKeachie, 2011, p. 190). Employing the use of instructional strategies to promote active learning is essential for high-risk students, such as those students in developmental education, because it requires students to be involved more in their own learning (Stahl, Simpson, & Hayes, 1992). According to Chickering and Gamson (1987), “learning is not a spectator sport” (p. 5). Students learn less when they are passively sitting and listening to lectures, and memorizing and recalling information. Learning must become part of the students, as they talk about learning, write about learning, and relate their learning to their everyday lives and experiences. As Cross (1991) explains, learning is not an additive process in which
knowledge just accumulates on top of existing knowledge, but is an active, dynamic process, in which knowledge is constantly changing and reformatting within the learner.

Additionally, a major factor in motivating students to learn, is when instructors use instructional strategies to promote active learning (Nilson, 2010; Svinicki & McKeachie, 2011), which is especially effective for teaching nontraditional students (Boylan, 2002). Doing something, or being engaged in the lesson, is generally more motivating and interesting for students, than just taking notes (Svinicki & McKeachie, 2011). Furthermore, Svinicki and McKeachie (2011) recommend college instructors use instructional techniques that allow college students to actively engage in the content, to help students store information in long-term memory by making use of the information within the context of the subject matter. Thus, the use of instructional strategies to promote active learning has the ability to foster more higher-order thinking as compared to traditional instructional strategies (Grubb et al., 1999; Nilson, 2010). Finally, employing instructional strategies to promote active learning also helps to eliminate the illusion that students understand the material (Svinicki & McKeachie, 2011). As students attempt to replicate the process and thinking required for a mathematical concept, misconceptions become more apparent to the instructor.

**Instructional Strategies to Promote Active Learning**

Understanding how students learn mathematics and becoming aware of which instructional strategies they should use to help their students become more successful should inform developmental mathematics instructors’ practice. According to a report by the National Research Council (NRC, 2000) titled *How People Learn*, there are many important classroom activities encouraging active learning that have been researched,
which fall under the heading of metacognition. “The science of learning suggest[s] that learning requires some sort of cognitive restructuring of material by the learner” (AMATYC, 2006, p. 53). When students become more aware of themselves as learners, transfer of information is improved and they are better able to monitor and assess their own learning (AMATYC, 2006). It is in the best interest of the students if instructors are able to help students understand the background knowledge they bring with them and help them to build upon that. Additionally, instructors should employ strategies to help students to engage in the material.

Instructional strategies for encouraging students to engage in active learning, as listed in Table 1, include: collaborative learning, cooperative learning, discovery-based learning, interactive lecturing, question posing, and writing (AMATYC, 2006). Whichever instructional strategy is chosen, the goal should be to enhance students’ conceptual understanding of the mathematics involved.

Collaborative learning is an activity that is unstructured “in which participants define problems, develop procedures, and produce socially constructed knowledge” (AMATYC, 2006, p. 53). In this activity, social skills are developed, student-student and student-faculty interactions are fostered, and students’ self-esteem is raised while increasing mathematics skills and knowledge. Cooperative learning is an instructional activity that is structured, in which groups of students are working to achieve a shared goal. According to Clark-Thayer and Cole (2009), cooperative learning involves activities planned and structured by the instructor. Generally, in practice, most group learning activities tend to be a mixture of collaborative and cooperative learning (AMATYC, 2006).
Other instructional strategies listed in Table 1 to promote active learning, include discovery-based learning, interactive lecturing, question posing, and writing. In discovery-based learning the instructor uses carefully designed questions and activities to lead students to make connections between new knowledge and their previous knowledge (AMATYC, 2006). Interactive lecturing, and question posing are questions and problems that instructors’ design to challenge, yet remain within students’ cognitive development. These activities have been shown to increase students’ active learning and their interest in the mathematics content. Finally, writing in mathematics is another active learning “strategy that can play an important role in the process of internalizing mathematical procedures, understanding the relationships of mathematical concepts, and synthesizing different mathematical components into a coherent schema” (AMATYC, 2006, p. 54).

Research in Undergraduate Mathematics and Science

When investigating what research says about the use of instructional strategies to promote active learning in undergraduate developmental mathematics classrooms, I found there to be very few studies in either undergraduate classrooms or in strategies to promote active learning. Because of this, I chose to review the literature from both mathematics and science undergraduate research studies.

Research Involving Developmental Mathematics

Shore and Shore (2003) investigated the changes in student academic performance due to the transformation of the developmental mathematics curriculum. The curriculum was redesigned from the traditional format in which students were passive learners, to a curriculum that allowed students to be actively engaged through problem-based learning (PBL) in meaningful health-care applications. When redesigning
the introductory and intermediate algebra courses for the experimental sections, concepts were specifically focused on nursing and allied health professionals, as well the perquisite topics they would need for subsequent mathematics courses. Additionally, the experimental sections implementing the PBL approach were not permitted to use calculators since the students in the allied health program could not use calculators when taking their Board Exams. The control sections of students enrolled in developmental mathematics that were taught using the traditional teacher-centered lecture format and were allowed to use calculators. Shore and Shore (2003) found the students who were enrolled in the PBL courses performed statistically higher on a post-test exam than the control students who had the advantage of using a calculator. Also, the PBL student performed statistically better than a peer group whom the same faculty had instructed the previous fall using the traditional format.

Research Involving Undergraduate Mathematics

Mullen (2012) conducted a research study in which she compared two approaches to teaching Real Analysis Mathematics; the traditional teacher-led lecture versus the reformist style implementing instructional strategies to promote active learning. These strategies included: assigning a reading prior to class with questions/problems within the reading; using class time to discuss the reading assignments in small groups or as a whole-class; assigning warm-up problems to be discussed in the following class; and finally assigning multi-part problems students were responsible for at the end of the week. Overall, Mullen (2012) found that using instructional strategies to promote active learning proved to be successful. She found the homework average improved from 53% to 70% and the exam scores improved from 53% to 62%. Since the same textbook,
homework, exam format, and exam problems were used in both the experimental class in which instructional strategies were used to promote active learning and in the traditional teacher-led lecture class, Mullen (2012) associated the gains in student academic performance were due to the strategies used to promote active learning. Students also indicated small group and whole class discussions were very helpful in understanding the material better.

In a study by Kasturiarachi (2004), cooperative learning was implemented as an instructional strategy to promote active learning in both pre-calculus and calculus courses across eight campuses. Three instructional strategies were implemented: Formatted Interactive Lecture Leaves (FILL), student projects, and the Program for Excellence in Mathematics (PEM). In FILL, students were given documents that were required to be completed during the lecture, consisting of definitions, examples, and illustrations. As students completed these forms throughout the lecture, they were engaged in interactive learning. Next, with student projects, students were required to complete several in-class mini-projects and then one end-of-semester group project with a presentation. These were incorporated as a way to bridge the connection between mathematics and students’ occupational interests. Finally, PEM was offered to students, but not required. In the PEM, cooperative learning was used in workshops to help students gain a deeper understanding of the content in their mathematics classes. From the study Kasturiarachi (2004), found students overwhelmingly indicated the worksheets were very helpful. Also, when working in small cooperative learning groups, students’ indicated they retained more when they worked with study groups and when they had to explain the material to others. Those students who participated in the PEM strongly agreed that the workshop
helped them analyze their thinking. Finally, the data indicated a strong positive correlation between students’ final course grades and the number of times they attended PEM.

**Research Involving Undergraduate Science and Mathematics**

Kim, Sharma, Land, and Furlong (2012), studied the changes in levels of students’ critical thinking when instructional strategies to promote active learning were incorporated in an undergraduate general science course. Three specific instructional strategies were implemented in an introductory geoscience course in which 155 students participated: group-based learning using authentic learning tasks, procedural and cognitive scaffolding, and two written individual reports.

In the first instructional strategy in which authentic learning tasks were implemented, students were involved in collaborative group activities to better understand the geoscience issues occurring in a natural disaster (Kim et al., 2012). For the second instructional strategy to promote active learning, procedural and cognitive scaffolding was employed. First, procedural scaffolding was used to show students the sequence of activities they should follow when reviewing complex problems. Next, cognitive scaffolding provided students with help for reasoning through complex, authentic problems. In the last instructional strategy used to promote active learning, individual written reports were used to allow students to review their reasoning of complex, authentic problems and synthesize group decisions. Two learning modules using the three techniques were implemented during weeks six and twelve of one semester. To examine the changes in critical thinking, the researchers created a rubric, which was used to assess the two written individual reports. Kim et al. (2012) found there
was significant improvement in the students’ performance scores of critical thinking between the two written reports. Thus, their study supports the notion that students’ critical thinking skills does improve when teachers incorporate instructional strategies promoting active learning. Additionally, the researchers found that students reported small-group learning allowed them to see how to approach authentic problems from different perspectives. Students also indicated the scaffolding guided them when evaluating resources and making justifications as they constructed arguments for their individual written reports.

Finally, in a recent meta-analysis by Freeman et al. (2014), they analyzed 225 studies containing data on examination scores and/or failure rates of student performance in undergraduate science, technology, engineering, and mathematics (STEM) courses, comparing the traditional lecturing approach to an active learning approach. They discovered that in those classes in which instructors employed strategies to promote active learning, their students’ average examination scores improved by six percent. Conversely, those students in which instructors used the traditional lecture-style, students were 1.5 times more likely to fail than those students whose instructors employed instructional strategies promoting active learning. Thus, Freeman et al. (2014) found in STEM courses “that active learning [led] to increases in examination performance that would raise average grades by half a letter, and that failure rates under traditional lecturing increase by 55% over the rates observed under active learning” (p. 1).

In summary, the studies reviewed here exemplifying different instructional strategies used to promote active learning, were associated with gains in student achievement. In those studies in which students were interviewed, it was reported that
students felt small group and whole class discussions were very helpful in understanding the material better. Additionally, engaging in collaboration with other students allowed them to hear different perspectives and build their skills for justifying and constructing arguments, which is so important in mathematics. Thus, the instructional activities in these studies support NCTM’s (2014) statement, “effective teaching of mathematics facilitates discourse among students to build shared understanding of mathematical ideas by analyzing and comparing student approaches and arguments” (p. 10).

**Importance of Using Strategies to Promote Active Learning in Mathematics**

According to the publication *Principles to Actions: Ensuring Mathematical Success for All* (NCTM, 2014), the prevailing cultural beliefs concerning the teaching and learning of mathematics continue to be an obstacle in what mathematics educators consider to be effective practices for the teaching and learning of mathematics. These cultural beliefs cause educators to continue to teach as they were taught, through rote memorization of facts, formulas, and procedures. This view of pedagogy perpetuates the traditional lesson model, which features the following steps: review, demonstration, and practice. In opposition to this view is the outlook based on “the belief that mathematics lessons should be centered on engaging students in solving and discussing tasks that promote reasoning and problem solving” (NCTM, 2014, p. 10). This view of mathematics instruction is very similar to the idea of implementing strategies to engage students in active learning, which requires students to do meaningful learning activities and think about what they are doing (Bonwell & Eison, 1991).

Effective mathematics teaching should support the two most valued learning goals in mathematics: procedural fluency and conceptual understanding (Hiebert & Grouws,
What is meant by procedural fluency is that students are allowed opportunities to become competent in executing mathematical procedures accurately and smoothly (Hiebert & Grouws, 2007). In conceptual understanding, students are allowed opportunities to become competent in making mental connections between mathematical facts, ideas, and procedures. Therefore, as students become mathematically fluent they are learning to choose flexibly between mathematical procedures and methods in order to solve problems; they are learning to explain why they chose to solve the problem using their approach; and they are learning to produce correct answers efficiently (NCTM, 2014). When mathematics procedures are connected to underlying concepts, students will be able to remember the procedures better and be better able to apply them in different situations.

The instructional strategies supporting procedural fluency include: asking higher-order questions, being clear when teaching, implementing whole-class direction, incorporating a task-focused environment, and having high achievement expectations for all students (Hiebert & Grouws, 2007). Additionally, Hiebert and Grouws (2007) state there are two main features of teaching that support conceptual understanding. First, research has shown that if teachers attend explicitly to mathematical concepts in their classroom teaching; to the connections between mathematical ideas, facts, and procedures, then students will develop conceptual understanding of mathematics. Second, students need to be given the opportunity to struggle with important mathematical ideas, meaning students need to spend time making sense of mathematics that is not immediately apparent. When students struggle with the mathematics, “they must work more actively and effortfully to make sense of the situation,” which allows them to
construct their own understandings of the activities rather than simply transferring the ideas from the teacher (Hiebert & Grouws, 2007, p. 389).

Instructional strategies defined as promoting active learning in mathematics should be centered on “prompt[ing] student interactions and discourse, with the goal of helping students make sense of mathematical concepts and procedures” (NCTM, 2014, p. 10). The teacher’s responsibility is to engage students in mathematical tasks that encourage reasoning and problem solving, as well as enable discourse that will help students work toward a shared understanding of mathematics ideas and concepts. This will enable teachers to allow for opportunities that involve student-student and student-teacher interactions (AMATYC, 2006). Additionally, instructional strategies used should require students to engage in the learning process at a higher-level of cognitive demand (NCTM, 2014).

**Importance of Using Higher-Level Thinking Tasks and Questions**

The mathematics tasks used by mathematics instructors should be chosen for their ability to engage students in problem solving and reasoning (NCTM, 2014). The tasks should have multiple entry points and should allow for multiple solution strategies. Additionally, the types of questions posed by mathematics instructors should encourage students to explain and reflect on their mathematical thinking. The questions should help both the instructor and student assess what he/she knows, help students to pose their own questions, and enable them to make important connections. It is critical for mathematics teachers to consider the cognitive demand of both the mathematics tasks and questions they will use.
The nationally recognized research project known as QUASAR (Quantitative Understanding: Amplifying Student Achievement and Reasoning) was enacted to offer meaning-oriented, high-level instruction to students in economically disadvantaged communities, who might have otherwise been relegated to lower-level, procedurally-based instruction (Stein & Lane, 1996). The results from the QUASAR Project revealed that the greatest gains in student achievement were related to the use of mathematics tasks that engaged students in high levels of cognitive demand, especially those tasks that encouraged non-algorithmic ways of thinking. The lowest gains of student achievement were related to the use of mathematical tasks that were procedurally based, and engaged students in low levels of cognitive demand. Thus, when instructional strategies allowed students to engage in mathematics tasks at a higher-cognitive level, as well as encouraging productive struggle, then students’ mathematical understanding increased. Mathematical tasks that create a higher cognitive demand for students will facilitate more conceptual understanding and are “essential for building students’ capacities to think and reason mathematically” (Stein et al., 2007, p. 379). These types of tasks, however, are the most difficult for teachers to enact.

A teacher’s professional identity or how they see their role as a teacher must also be considered when planning the type of activities they will implement in their teaching (Stein et al., 2007). Identity affects what the teacher knows, feels, and is inclined to do within mathematics, whether that is focusing on activity and inquiry-based learning versus memorizing and following procedural rules. A large factor of a teacher’s professional identity is how they create their role relative to their students. According to Stein et al. (2007), many times teachers “associate good teaching with telling and
showing students what to do” (p. 354). Employing instructional strategies that promote active learning will outline a much less didactic role for the teacher, which may result in some discomfort for teachers since these teaching strategies are not the norm. Additionally, if the activities that are planned include tasks that allow students to engage in mathematics at a higher-cognitive level, even more is being asked of the teacher. Stein et al. (2007), indicates that teachers in these situations will have to cultivate a tolerance for discomfort as they reconstruct their professional identities.

NCTM’s (2014) *Principals to Actions* recommends that in addition to selecting good mathematical tasks to allow students to reach their learning goals, mathematics teachers should also: create a classroom environment that is conductive to learning; conduct stimulating classroom discourse and effectively manage that discourse; and assess student learning so that instructional changes can be made to improve student learning. Thus, teachers must give students the opportunity to participate by both working through problems individually as well as attending to the solutions of other students (Franke, Kazemi, & Batter, 2007). In order to give students these opportunities, the teacher must foster an environment rich in discourse that supports and is productive for students. Teacher questioning is vitally important to directing student responses towards purposefully focused mathematical thinking. Teachers should use a variety of questions to assess student thinking and learning, probe their understanding, make mathematics more obvious, and ask students to reflect on and explain their thinking (NCTM, 2014).

In order for instructors to allow students to reach a higher-level of cognitive learning, the mathematics tasks and questions that instructors employ must promote reasoning and problem solving. It is imperative that instructors pay attention to the types
of mathematics tasks they are using in their instruction, for “not all tasks provide the same opportunities for student thinking and learning” (NCTM, 2014, p. 17). Likewise, it is very important for instructors to pay attention to the types of questions they are using to facilitate academically productive talk. Therefore, in order to assess the quality of mathematics instruction it is necessary to attend to the cognitive complexity of the tasks implemented as well as the nature of the instructor’s questions (Mesa et al., 2014). One way of capturing the complexity of tasks would be through the use of The Task Analysis Guide created by Smith and Stein (1998, p. 348) in which mathematical tasks are categorized from lower-level demands to higher-level demands to aid in determining the cognitive complexity of the mathematics tasks (see Table 2).

In the Task Analysis Guide, tasks are ranked from lower-level to higher-level in the following order: memorization tasks, procedures without connections tasks, procedures with connections, and doing mathematics (Smith & Stein, 1998).

Memorization tasks (low-level) involve reproducing previously learned facts, rules, and procedures. The tasks are not new to students. Procedures without connections tasks (better tasks, but still considered to be low-level) are algorithmic and require little cognitive demand to be successful. There are no connections to concepts and the purpose is to produce a correct answer. Procedures with connections tasks (high-level) are usually represented in multiple ways, allowing students to make connections between multiple representations in order to create meaning. These tasks require some amount of cognitive effort. Doing mathematics tasks (considered the best and most challenging, high-level) require students to analyze and explore the task, using their knowledge of mathematical concepts and relationships. These tasks require a significant amount of cognitive effort.
As developmental mathematics instructors engage their students in active learning, they must be mindful of the cognitive levels of the mathematics tasks and questions they pose. Instructional tasks influence student learning by structuring the kind and level of classroom discourse that occurs (Stein & Lane, 1996). When the mathematical tasks in which students are engaged in require limited thinking and reasoning, it is difficult to for instructors to promote more meaningful, extended forms of discussion. Thus, implementing tasks questions at a higher cognitive level will allow students to actively engage in inquiry and analysis and to use mathematical procedures in ways that are more meaningfully connected to mathematical concepts (NCTM, 2014).
CHAPTER 3: METHODOLOGY

Design of the Study

In order to answer the research questions for this study, I chose to use a mixed methods design, combining both quantitative and qualitative approaches in the methodology of a study (Tashakkori & Teddlie, 1998). Creswell and Clark (2011) expanded their definition of mixed methods research to combine fundamental components, such as philosophy, methods, and the research design orientation. This means, in a mixed methods research study, the researcher:

- Collects and analyzes persuasive qualitative data and rigorous quantitative data;
- Merges the two forms of data, either concurrently or sequentially;
- Gives priority to one or both forms of data, depending on the emphasis of the research questions;
- Uses these procedures within a single study or multiple phases within a large research study;
- Frames the procedures of the study within a philosophical worldview; and
- Combines the procedures of the study to aid in directing the plan for how the research is to be conducted (Creswell & Clark, 2011, p. 5).

I chose to use a sequential mixed method design (Creswell, 2009) for this study, because I compared and expanded what I learned from the quantitative data and initial qualitative data with more extensive qualitative data. To begin with, a survey was employed to obtain initial qualitative data using an open-ended question to have instructors describe the instructional strategies they employed to engage students in the learning process. Sequential questions followed to gather quantitative data about the instructional strategies
developmental mathematics instructors rated as most important and employed. Demographic questions followed. Next, I chose three participants from the survey for case study analysis to conduct three observations, three post-observation interviews, and collect artifacts to obtain additional qualitative data.

Creswell and Clark (2011) further developed the sequential mixed method into two different two-phase designs: the explanatory sequential design and the exploratory sequential design. The explanatory sequential design begins with quantitative data collection and analysis, followed up with qualitative data collection and analysis, and finally ending with an interpretation of the data. The exploratory sequential design begins with qualitative data collection and analysis, building to a quantitative data collection and analysis, and ending with an interpretation of the data. For this study I implemented the explanatory sequential mixed methods design because I first collected quantitative data and some initial qualitative data, followed by a more thorough collection of qualitative data. This type of research design has also been known as a qualitative follow-up approach (Creswell & Clark, 2011). In this study the additional qualitative data from the case studies will serve as a means of illustrating the initial quantitative and qualitative findings.

The main purpose of an explanatory sequential mixed methods research design is to use a qualitative component to explain the initial quantitative results (Creswell & Clark, 2011). This type of design is also used when the researcher wants to use the participants’ characteristics and responses to guide the purposeful sampling to be used during the qualitative phase. The quantitative strategy of inquiry I implemented was a single-stage survey, for I had access to the names of the participants and could sample
them directly (Creswell, 2009). The advantage of using surveys is that they can provide a numeric description of trends and opinions of a population. A survey method is used to answer the “who,” “where,” and “how many” of the research problem (Yin, 2014). The qualitative strategy of inquiry I chose to implement is case study inquiry. In case study research, the researcher investigates an event, process, or individual in depth (Creswell, 2009). Each case is bound by a time frame and action, and the researcher collects detailed information through multiple data collection procedures. The case study method is used to answer the “how” and “why” questions, which are more explanatory and lend themselves to a qualitative research analysis (Yin, 2014). Additionally, the case study is used to help the researcher understand a set of decisions: why they were made, how they were enacted, and what the results were. A case study inquiry “relies on multiple sources of evidence, with data needed to converge in a triangulating fashion” (Yin, 2014, p. 17).

The types of information I collected from this phase of the research included: field study notes from the observations, an audio recording of each classroom observation, lesson plans, artifacts from the lesson, and post-observation interview notes along with the audio recordings of these interviews.

An explanatory sequential mixed methods research design thus described the study I undertook, because I used a survey to gather quantitative data about participants’ characteristics and their responses concerning instructional strategies that promote active learning. Additionally, using the data gathered from the survey, I purposefully selected three participants for the qualitative part of the study implementing a multiple-case study design (Yin, 2014). Additionally, in the survey I included a question asking instructors if they were willing and interested to allow me to make three classroom observations in one
of their developmental mathematics courses. From the pool of respondents who consented to allow me to make observations in their classroom, the three participants were chosen using the following criteria:

1. indication of instructional strategies used to engage students in the learning process,
2. allotted time set for the developmental mathematics courses they taught,
3. type of developmental mathematics course they taught,
4. time during the day, as well as time during the week they taught, and
5. proximity of the community college of each participant to Columbia, MO.

Each instructor was considered a unit of analysis for the case study. The advantage of using a multiple-case design over a single-case design is that the study becomes more persuasive, thus making the study more robust (Yin, 2014).

The three case study participants’ responses about the types of instructional strategies they used to engage students in the learning process that were self-reported in the survey were compared to the instructional strategies I observed in their classrooms. Additionally, from both the survey and post-observation interviews, I gathered information in order to recommend needed professional development that was suggested by the participants to help instructors engage students in the learning process. Finally, the observations allowed me to categorize the cognitive level of the mathematics tasks and questions used by the participants in their instructional strategies. The use of the survey and case study allowed me to answer my research questions:

1. How do Missouri community college developmental mathematics instructors describe the instructional strategies they use to promote active learning?
2. What instructional strategies used to promote active learning, as recommended by the American Mathematical Association of Two-Year Colleges (AMATYC), do developmental mathematics instructors rate as important and indicate they employ in their classrooms?

3. What is the cognitive complexity of the mathematical tasks and questions employed by the instructors during the instructional strategies?

4. What types of professional development do Missouri community college developmental mathematics instructors indicate is needed in order to successfully implement instructional strategies to promote active learning in their instruction?

There were several advantages for choosing the explanatory sequential mixed method research design (Creswell & Clark, 2011).

- This type of design appeals to quantitative researchers, because it begins with a strong quantitative emphasis. Prior to working in education, I used quantitative research methods in my engineering work experiences. Asking “if, then” statements was very comfortable for me.

- Another advantage is how the two-phase structure of the explanatory mixed method design is straightforward when putting it to practice. The research data are collected one type at a time, making it more feasible for a single researcher to carryout.

- Finally, the final report on the results can be written in two sections; the quantitative section followed by the qualitative section. This makes writing the report more straightforward and makes the report easier to read.
The explanatory mixed methods research design was most appropriate to achieve my objectives because I had specific variables, instructional strategies to promote active learning, which could be measured using a survey. Additionally, the survey allowed me to purposefully select the participants for the qualitative data collection. Finally, this type of design worked well for my study because I was the only researcher working on this study, meaning there were limited resources; and a research design was needed where I could collect and analyze one type of data at a time.

**Research Paradigm**

The philosophical foundation of a research study shapes the assumptions the researcher makes about gaining knowledge during the study (Creswell & Clark, 2011). These assumptions, or the paradigm worldview, shape the processes of one’s research study and how one conducts’ their inquiry. In this explanatory sequential mixed methods study a pragmatic worldview (Creswell, 2009) was used for several reasons. To begin with, because this research drew from both quantitative and qualitative methods, there were multiple types of philosophy I drew from as I engaged in my research. Having a pragmatic worldview allowed me to be free to utilize the methods and procedures that best met the needs of my research. Second, the pragmatic worldview emphasized the research problem and focused on what worked or what approaches were available for understanding the problem, rather than focusing on the methods. Finally, “the pragmatist researchers look to the *what* and *how* to research, based on the intended consequences – where they want to go with it” (Creswell, 2009, p. 11). In the pragmatic worldview, truth is what works at the time of the study (Creswell, 2007).
Participants

The initial participants for this study were the developmental mathematics instructors from all 13 of Missouri’s 2-year public community colleges (CCs):

1. Crowder College (CC)
2. East Central College (ECC)
3. Jefferson College (JC)
4. Metropolitan Community College of Kansas City (MCCKC)
5. Mineral Area College (MAC)
6. Missouri State University – West Plains (Missouri State)
7. Moberly Area Community College (MACC)
8. North Central Missouri College (NCMC)
9. Ozarks Technical Community College (OTC)
10. St. Charles Community College (SCC)
11. St. Louis Community College (STLCC)
12. State Fair Community College (SFCC)

By including all of the Missouri public CCs in the study, I maximized the number of developmental mathematics instructors I was able to survey.

Next, I obtained IRB Approval from the University of Missouri to proceed with this research study (Appendix A). Aiding me in the process of contacting the CCs Chief Academic Officers (CAOs) for this study was Dr. Terry Barnes, who is the University of Missouri Columbia’s Assistant to the Provost for Community College Partnerships. Working alongside Dr. Barnes, we prepared a letter that was sent to the Presidents and
CAOs of the CCs (Appendix B). This letter served two purposes. First, the letter explained the purpose of my survey and requested permission for me to survey the instructors. Additionally, permission was requested to personally observe some of their developmental mathematics instructors who had given permission on the survey and indicated they were actually using instructional strategies that promoted active learning. The second purpose of the letter was to ask the Presidents and CAOs to forward our intentions to the mathematics departments to survey the FT and PT adjuncts teaching developmental mathematics courses and ask for permission to contact them to develop a survey directory.

In the event that I did not hear back from some of the CCs, I had created a directory of all the instructors teaching developmental mathematics at each of the CCs by going to website of each CC and utilizing the Fall 2014 schedule of classes. Prior to contacting the CAOs, I contacted a representative from the University of Missouri (MU) Institutional Review Board (IRB) about the permissions required for this study. The IRB representative informed me that permission was not required to send a survey to the instructors, which is one of the reasons I created a directory of all the developmental mathematics instructors. I also made this directory prior to my dissertation proposal so that I could estimate approximately how many instructors might be participating in the survey. The IRB representative also informed me that when it was time to go to the CCs to observe an instructor for the case study, a permission letter would be required from those CCs as part of the IRB process (Creswell & Clark, 2011).

From the CAOs of the 13 CCs, I obtained permission or IRB approval from their institutions, as well as the names of the Mathematics/Developmental Education Instructor
Chairs to get the names of the developmental mathematics instructors. The total number of instructors that I sent surveys to was 494.

Of the 31 respondents who consented to allow me to make observations in their classroom, three participants were chosen for the case studies based on the following criteria:

1. *How participants described the instructional strategies they used to engage students in the learning process, rated the importance of, and implemented various instructional strategies, through survey questions 1, 2, and 3.* I identified participants who indicated a higher use of instructional strategies to promote active learning rather than those who prefer to use passive, traditional lecture-style strategies.

2. *The amount of allotted time for the developmental mathematics courses the participants taught.* I chose those participants who taught for approximately the same amount of time in their classes, to aid in dependability of the study. For example, all the instructors taught approximately 1 hour 15 minutes to 1 hour 25 minutes twice a week as opposed to a 3-hour class once a week.

3. I selected instructors who *taught different types of developmental mathematics courses,* because it was important to verify that instructional strategies to engage students in the learning process were being implemented at all levels of developmental mathematics courses. I did not observe across multiple types of classes of the same instructor for there was no time in this study for those types of observations.
4. I selected instructors based on the time during the day, as well as the time during the week they taught so that I could coordinate more than one instructor on the same day. Also, I had to be sure the days I was observing was not on the same days I was teaching.

5. The proximity of the community college of each participant was no further than 2 hours from Columbia, Missouri.

The IRB approval letters from the CCs for the three instructors who were chosen to participate in the case studies are given in Appendix C.

Data Collection Instruments and Management Techniques

The data collection instruments for this study include the survey, classroom observation, and post-observation interview protocols. I designed all of these instruments for this study using various sources, due to the unavailability of instruments in the research literature and the particular nature of this study. Care was taken that the instruments created for this study were credible by reviewing previous documents and instruments, having experts in the field review the protocols, and piloting the protocols.

Instructional Strategies to Promote Active Learning Survey Protocol

The survey used for the quantitative section of the study was created through the compilation of several sources. The framework of Instructional Strategies That Promote Active Learning in the AMATYC (2006, p. 54) document was used because of its significance for mathematics instructors in 2-year colleges (Table 1). Additionally, items on the survey concerning the instructor characteristics were based on items uncovered in the literature review and from the Michigan Community College Math Faculty Survey
instrument (Andersen, 2011). Furthermore, Dr. V. Mesa and Dr. T. Barnes, who are experts in the field of developmental education, critiqued the survey.

Additionally, to check for clarity, comprehensiveness, and acceptability, two developmental mathematics instructors from Columbia College pre-tested the survey (Rea & Parker, 2005). It was important to field test the survey in order to establish its content validity, and improve the questions and format (Creswell, 2009). The Qualtrics survey creation tool http://www.missouri.qualtrics.com was used to create the survey and was used to administer the survey. The IRB Office of Research at MU recommended the use of this survey tool, because it met the security standards for the university.

The survey was sent, blind-copied, to the participants and was administered online. The advantages to conducting a web-based survey are: convenience, efficient data collection, cost-effectiveness, ease of follow-up for reminders, and confidentiality and security (Rea & Parker, 2005). The disadvantages include: limited response by those who feel comfortable in their computer literacy to participate, and limited response by those who do not understand the questions. However, more and more people are becoming comfortable using computers for many things, which may have helped the response rate.

Prior to receiving the survey via email, the participants received an introductory letter from myself (Appendix D), which also gave a brief purpose of the study. At the end of this letter was a link to the survey ( Appendix E). Once the participants opened the link to the survey, the first Survey Question (SQ – 1) was consent information stating: the purpose of the research; what the participants were asked to do; a list of the benefits and risks of being in the study; the confidentiality statement; freedom to withdraw; consent statement; and who to contact with questions or concerns. After the participants indicated
they had read and understood the conditions of the study by checking the circle, they were able to continue the survey.

The survey was created for this study for the following reasons: to aid in answering three of the research questions for this study and to obtain instructors to observe for the case studies. The three research questions the survey were to aid in answering are:

1. How do Missouri community college developmental mathematics instructors describe the instructional strategies they use to promote active learning?

2. What instructional strategies used to promote active learning, as recommended by AMATYC, do developmental mathematics instructors rate as important and indicate they employ in their classrooms?

4. What types of professional development do Missouri community college developmental mathematics instructors indicate is needed in order to successfully implement instructional strategies to promote active learning in their instruction?

The survey began by asking the respondents questions about information that would answer the research questions, followed by demographic questions. The demographic questions were located near the end of the survey because they may have generated stereotype threat (personal communication, V. Mesa, July 2014). Additionally, the survey was created in such a way that the participants were not able to go back to the previous questions. The reason for this was because in SQ – 3 and SQ – 4, the list of learning strategies for promoting active learning was given from AMATYC (2006). In SQ – 2 the participants were asked to describe the strategies they felt were the most
effective for engaging students in the learning process, thus I did not want the ideas from SQ – 3 and SQ – 4 to sway the answers they gave in SQ – 2.

After instructors’ gave consent to participate in the survey, a definition was given for developmental mathematics, so that all the respondents understood what this term meant with respect to this study. The second question of the survey asked the participants to describe two strategies that they felt were the most effective for engaging their students in the learning process in developmental mathematics, which aided in answering research question one. The third survey question asked the participants to rate the importance of a given set of teaching strategies that were adapted from AMATYC’s (2006) list of instructional strategies recommended to promote active learning, which aids in answering the first part of the second research question. The fourth survey question asked the participants to describe their implementation of a given set of instructional strategies (same list from SQ – 3), which aided to answer the second part of research question two: which strategies to promote active learning do the instructors indicate they employ in their classroom. Survey question three also served to answer research question four, concerning the type of professional development that instructors indicate is needed for them to successfully implement instructional strategies to promote active learning in their classroom. While the information I gathered from SQ – 2, SQ – 3, and SQ – 4 aided in helping me to answer research questions one, two and four, one has to remember that these were self-reported data. The observations that I conducted of three of the individual instructors for the case study section of this project allowed me to witness whether the instructional strategies for promoting active learning were actually being used in the classroom. Thus in order to triangulate the data, I compared the data from the survey with
the qualitative data from the case study analysis for the same three participants in the final analysis.

The next two questions, SQ – 5 and SQ – 6, asked the participants which of the instructional strategies listed in SQ – 4 would they use or would they NOT use to engage students in the learning process when teaching a developmental mathematics course, and to explain. Questions, SQ – 7 and SQ – 8, asked the participants which of the instructional strategies listed in SQ – 4 would they use or would they NOT use to engage students in the learning process when teaching a credit-bearing college-level mathematics course, and to explain. According to Grubb et al. (1999), instructors tend to believe that those students in developmental mathematics learn best when traditional instructional methods are implemented. Likewise, they believe students in higher-level mathematics courses are able to succeed when more student-centered instructional methods are used, such as instructional strategies to promote active learning. Thus, I investigated whether this was true. Finally, SQ – 9 asked participants to list the course textbooks (curriculum) that they were currently using.

The purpose of questions 10 through 14 was to learn some demographic information about the developmental mathematics instructors from Missouri’s CCs. This information includes whether they were considered a FT or PT employee; the types of institutions they had taught at and the number of years at each of the institutions; what types of degrees and majors they had earned; the professional societies they belonged to; and the developmental mathematics courses they were currently teaching and when. This information allowed me to report some of the background and skills of developmental
mathematics instructors in Missouri, and I was able to analyze this information with respect to whether they were PT or FT faculty.

The survey concluded by asking if the participants would allow me to observe their developmental mathematics courses during the Fall (2014). If the participants chose “yes” or “maybe” they were taken to the next question asking for their contact information. If they chose not to allow me to observe their classes, the survey concluded without asking for their contact information.

**Consent to Participate in the Research Study**

Prior to observing the three instructors who were chosen to participate in the case study research, I had them sign a consent form (Appendix F). This form contained consent information stating: the purpose of the research; why the research study was being done; how many people would be in the study; what the participants were asked to do and how long it would take; a list of the benefits and risks of being in the study; the costs of being in the study; the confidentiality statement; their rights as a participant; and who to contact with questions or concerns. After the consent information was read, signed, and dated, the instructors were able to participate in the study.

**Classroom Observation Protocol**

The Classroom Observation Protocol (Appendix G) was created in part from the framework from AMATYC (2006), as well as from a classroom observation protocol that was created for the Practices Project (Otten, Engledowl, & Spain, 2014). The purpose of the observation was to answer what instructional strategies to promote active learning do developmental mathematics instructors employ in their classrooms and what was the
cognitive complexity of the mathematical tasks and questions employed by the instructors during the instructional strategies?

The observation protocol contained two parts. First, information was gathered on this sheet that includes: the name of the instructor being observed, the institution, the name of the course that was observed, the time of the lesson, the textbook and the pages used, the number of students present, and the seating arrangement.

As I took notes every 4 to 5 minutes, I recorded the time and the corresponding events:

- The instructional strategies used during the class,
- The questions the teacher posed,
- The mathematics tasks the teacher presented to the students, such as the exercises and examples being worked and discussed in class on the board, and/or from their books or worksheets,
- The use of any instructional materials (by the teacher or students), such as manipulatives, technology, or worksheets,
- How students were grouped and the expectations of the students while in their groups, and
- Out of class assignments whenever possible.

In these field notes I indicated the instructional strategies that promoted active learning by the use of a code from the AMATYC (2006) list of strategies. By indicating in the field notes where I saw specific instructional strategies used to promote active learning, it was easier for me to later locate these strategies for which I should analyze the cognitive-levels of the tasks and questions used. Additionally, the classroom observations were
audiotaped so that I could compare the transcription notes with the field notes for credibility.

**Post-Observation Interview Protocol**

The final instrument that was used in this study was the Post-Observation Interviews (POI) Protocol (Appendix F). This instrument contained three separate interview protocols. Using the interview style proposed by Seidman (2013), three distinct interviews were conducted in order to better understand the experience of the participant and the meaning they made of their experiences, which is based in the phenomenological tradition. In the first interview, the interviewer asks participants to put their experience in context by having them discuss themselves. In the second interview, the interviewer asks participants to talk about their present experience within their area of study. Finally, in the third interview, the interviewer asks participants to reflect on their experiences within their area of study. For this study I created three separate interviews that reflect Seidman’s (2013) ideas, as discussed in more detail in the following paragraphs.

The purpose of the post-observation interview protocol was to gather additional information about the instructors’ thoughts concerning the instructional strategies they had implemented to engage students in the learning process. The information gathered over the course of all three interviews were meant to help answer research questions one, three, and four. For research question one, I was seeking to learn how the instructors described the instructional strategies they used to promote active learning. In order to answer research question three, I asked the instructors how they chose the mathematical tasks they used and the questions they posed to see if they were attempting to enact high-level mathematics tasks and maintain this level of cognitive complexity when engaging
students in the learning process. Finally, for research question four, I asked the instructors what type of instructional support they felt would be helpful for them in designing and/or implementing strategies in their instruction. See Table 5 in the Data Analysis Procedures section of this chapter to see how the POI questions served to answer each of the research questions. The interviews were audio recorded, in order to transcribe the interviews for qualitative analysis.

The over-arching focus that I was asking participants about in all three of the interviews considered the types of instructional strategies they used to engage the students in the learning process. Each interview was made up of 10 questions and lasted approximately 30 – 45 minutes. In the first interview I asked the participants questions about: their background teaching developmental mathematics courses; the types of strategies they used to engage their students in the learning process in that day’s lesson; and the kind of support they felt they needed or did not need to help them engage their students. The next interview consisted of questions about: the types of strategies the participants used to engage the students in the learning process in that day’s lesson; the kind of support they felt they needed or did not need to help them engage their students; and how they used the curriculum to engage students. The third and final interview consisted of questions about: the types of strategies the participants used to engage the students in the learning process in that day’s lesson; the kind of support they felt they needed or did not need to help them engage their students; and the instructors’ beliefs concerning instruction for developmental mathematics students. From the post-observation interviews I gained insightful information that I otherwise would not have been able to obtain from the survey or the classroom observations.
Data Management

As stated in the consent forms (Appendix F), the information produced by this study was stored in the investigator’s file and identified by pseudonym only. The key connecting the pseudonyms to specific information about the participants were kept in a secure location. Information contained in participants’ records was not given to anyone unaffiliated with the study in a form that could identify them without their written consent, except as required by law.

Audio recordings taken during the observation phase of the study that could identify the participants were not used without their special written permission. In that case, they were given the opportunity to listen to the audio recordings before they gave their permission for their use if they so requested.

Data Analysis Procedures

I gathered both quantitative and qualitative data to illuminate the specific themes about the types of instructional strategies developmental mathematics instructors were employing to promote active learning (Creswell, 2007). In the sequential explanatory design used for this study the procedures flowed as shown in Figure 1.

![Sequential explanatory design](Creswell, 2009, p. 209).

The quantitative data were collected and analyzed in the first phase of the research, as well as a limited amount of qualitative data were collected but not analyzed; and then in the second phase of the research, the majority of the qualitative data were collected and
all the qualitative data were analyzed (Creswell, 2009). The linear nature of this research design was an advantage to using this type of mixed methods research.

For this study I used a deductive process when analyzing the data. I began by assigning primary and secondary codes using the theoretical AMATYC (2006) framework for coding the instructional strategies described and worked through the data to notice emerging patterns (Bernard & Ryan, 2010). When coding for the cognitive complexity of the tasks and questions, I used the frameworks given in Tables 2 and 3. The deductive strategy was especially useful when employing a mixed methods design. The qualitative data from the observations aided in explaining and/or confirming the information learned from the quantitative data (Bernard & Ryan, 2010).

At the beginning of the data analysis, the survey provided both statistical and descriptive information about the participants, as well as provided qualitative data through an open-ended question when participants were asked to describe the instructional strategies they used to promote active learning. Next, the qualitative data collected from the second question of the survey and the case studies were coded to find the themes and patterns from the data. Finally, the data analysis from the quantitative and qualitative data, were combined to develop a final analysis of all the data with respect to the research questions. Having the ability to mix both quantitative and qualitative data was an advantage because the findings of the three participants who participated in both the survey and case studies were triangulated and mutually corroborated, giving the study greater credibility to the findings (Creswell & Clark, 2011). I used the web application Dedoose (www.dedoose.com) to manage the data analysis for this study because this platform had the ability to analyze mixed methods research.
Quantitative Data Analysis

As part of the data analysis I gathered the response rate of the survey (Creswell, 2009). Two reminders were sent to aid in the response rate of the survey. Using the Qualtrics survey tool a descriptive analysis of the quantitative survey questions was completed. From the quantitative data a descriptive analysis of the following was determined:

- How developmental mathematics instructors rated the importance of instructional strategies for promoting active learning as proposed by AMATYC (2006);
- How developmental mathematics instructors described their implementation of the instructional strategies for promoting active learning as proposed by AMATYC (2006); and
- The demographic information (work status, academic teaching experience, education, professional status, and current teaching status).

The descriptive analysis included the measures of central tendency: frequency, means, and percentages (Rea & Parker, 2005). The instructor characteristics or demographics were gathered from both the survey questions and POI questions. The information on the instructors’ characteristics were used to aid in describing developmental mathematics instructors in Missouri CCs. Table 5 shows the breakdown of the questions that were used to collect data on instructor characteristics for the quantitative analysis.
Table 5

Survey and POI Questions Used to Collect Data on Instructor Characteristics

<table>
<thead>
<tr>
<th>Instructor Characteristic</th>
<th>Description of Questions</th>
<th>Survey or POI Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work status</td>
<td>FT or PT</td>
<td>SQ – 10</td>
</tr>
<tr>
<td>Academic teaching experience</td>
<td>Types of institutions taught at and number of years at each</td>
<td>SQ – 11</td>
</tr>
<tr>
<td>Education</td>
<td>Degrees and majors earned</td>
<td>SQ – 12</td>
</tr>
<tr>
<td>Professional status</td>
<td>Professional society membership</td>
<td>SQ – 13</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SQ – 14</td>
</tr>
<tr>
<td>Developmental mathematics interest</td>
<td>How the instructor got started teaching developmental mathematics</td>
<td>POI – 1st Interview</td>
</tr>
<tr>
<td>Training</td>
<td>Training given to teach developmental mathematics</td>
<td>POI – 1st Interview</td>
</tr>
</tbody>
</table>

Note: POI = Post-Observation Interview, SQ = Survey Question

Qualitative Data Analysis

The initial qualitative data were first coded into meaningful segments using assigned codes (Creswell, 2007). According to Marshall and Rossman (2011), “the researcher should use preliminary research questions and the related literature developed earlier in the proposal as guidelines for data analysis” (p. 209). Following the direction of Marshall and Rossman (2011), I used the framework of instructional strategies that promote active learning (AMATYC, 2006) to create initial primary codes (bolded headings) and secondary codes (strategies below the bolded headings) to guide my analysis of the instructors’ descriptions from SQ – 2. As I analyzed the data, I also looked for emerging codes that described the instructional strategies the developmental mathematics instructors used to engage students in the learning process. These emerging codes either became new primary codes, such as Exhibiting Enthusiasm & Encouraging Students, or they fit under existing primary codes such as Interactive Lecturing in which
the emerging secondary code was Giving students note packets to fill out. A sample of the coding scheme that I employed appears in Table 6 along with examples of some of the new primary and secondary codes, which are underlined to denote they were not part of the original AMATYC (2006) framework.

Table 6


<table>
<thead>
<tr>
<th>Original Codes From the AMATYC (2006) Framework</th>
<th>Coding Scheme Employed in Dedoose, Including Primary and Secondary Codes Created From Original Framework and New Primary Secondary Codes</th>
</tr>
</thead>
</table>
| **Cooperative Learning**                        | ❖ Cooperative Learning  
❖ Pairs solve a textbook problem  
❖ Pairs explain problem  
❖ Pairs discuss correct solution  |
| **Interactive Lecturing**                       | ❖ Interactive Lecturing  
❖ Students compare processes  
❖ Solve using alternative methods  |
| **Exhibiting Enthusiasm & Encouraging Students**| ❖ Exhibiting Enthusiasm & Encouraging Students  |
| **Computer-Assisted Technology**                | ❖ Computer-Assisted Technology  |

On the following page is a sample of the transcription and the coding that was created when using Dedoose (Figure 2). In the figure a selection of transcription is
provided from one of the teacher observations. Below Figure 2 is an explanation of how the tasks, questions, and instructional tasks were coded.

Figure 2. Sample of transcription using Dedoose.
As I transcribed each of the observations, I labeled the tasks with a “T” in bold and the instructors’ questions with a “Q” to make it easier for me to find them during the coding process. Each task was first coded, followed by coding the questions for the task, and finally coding the instructional strategy the teacher employed during the solving of the task. This was done in order to determine the cognitive complexity of the tasks, the cognitive complexity of the questions, and whether the instructional strategy employed was one the participant indicated they used when they had previously answered the survey (for triangulation checking). The cognitive complexity of the tasks and questions was determined to answer research question 3.

In Figure 2, I coded the task highlighted in red as L3, a procedures with connections task (using Table 2), because the task required some degree of cognitive effort. In order to solve this problem, students had to have a deeper understanding of mathematical concepts and ideas (Smith & Stein, 1998). The question highlighted in blue, I coded as Q1.1 (using Table 3), Gathering Information – Factual Knowledge. At first it appears the question may be seeking a higher level of knowledge, however, once the teacher starts playing hangman with the students to help them remember the mathematical term, I felt that that she was having the students retrieve knowledge. Thus, in order to code the tasks and questions, I had to read the transcription prior to and after the text I was to code to gain the correct context of the situation.

For the question highlighted in green in Figure 2, the instructor is making sure the students understand the average rate of change for this problem represents the slope. The instructor’s question, “Do you agree with that?” is in reference to having to use two points to find the slope \( m = (y_2 - y_1)/(x_2 - x_1) \), thus I coded this question as Q2.2,
Probing Thinking – Procedural Knowledge. However, at first glance, one might think it would be a yes/no question and possibly code it as Q1.1. For the question highlighted in yellow, in which students were asked how they should think about the slope in terms of two points using this real-world problem. The students had to understand mathematical structures and make connections among mathematical ideas (NCTM, 2014). Because of the deeper level of understanding that was occurring, I coded this question as Q3.3, Making Mathematics Visible – Conceptual Knowledge. Finally, for the questions highlighted in purple and orange, the students were being asked why the percent of smokers would change with the year. These questions were coded as Q4.4, Encouraging Reflection & Justification – Meta-Cognitive Knowledge because the students were analyzing the problem and attempting to make an argument for why the percent of smokers would change over the years.

The last thing I coded for each task after coding all the questions, was the instructional strategy the teacher used to promote active learning during the task. For the task in Figure 2, I coded the primary code for the instructional strategy as Question-Posing, with the use of Guiding Questions to help solve the task as the secondary code. This process, the coding of tasks and questions for the cognitive complexity and the corresponding instructional strategy the teacher used to promote active learning during the task, was completed on all nine of the observations that were made for the three participants.

Using the data from the qualitative survey question (SQ – 1) and the three case studies, I compared the instructional strategy codes that had emerged from the data to further develop my categories, and then compared the categories that were developed
back to the data (Saldana, 2009). This process illustrates how qualitative inquiry is cyclic in nature. Next, I started looking for patterns across all the data sources, both quantitative and qualitative. According to Creswell and Clark (2011) “triangulation or greater validity refers to the traditional view that quantitative and qualitative research might be combined to triangulate findings in order that they may be mutually corroborated” (p. 62).

Table 7 gives a brief description of analysis that was used for each of the research questions of this study.

Table 7

*Description of Data Analysis for Each Research Question*

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Survey Items &amp; Qualitative Data Items</th>
<th>Data Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. How do Missouri CC developmental mathematics instructors describe the</td>
<td>SQ – 2 1&lt;sup&gt;st&lt;/sup&gt; POI 2&lt;sup&gt;nd&lt;/sup&gt; POI 3&lt;sup&gt;rd&lt;/sup&gt; POI</td>
<td>Statistical analysis of SQ – 2 using Dedoose and SQ – 3 using Qualtrics. POIs transcribed, coded for instructional strategies, and finding of themes or patterns.</td>
</tr>
<tr>
<td>instructional strategies they use to promote active learning?</td>
<td>SQ – 3 SQ – 4 FN 1&lt;sup&gt;st&lt;/sup&gt; POI</td>
<td></td>
</tr>
<tr>
<td>2. What instructional strategies used to promote active learning, as recommended by AMATYC, do developmental mathematics instructors rate as important and indicate they employ in their classrooms?</td>
<td>FN 1&lt;sup&gt;st&lt;/sup&gt; Observation-POI 2&lt;sup&gt;nd&lt;/sup&gt; Observation-POI 3&lt;sup&gt;rd&lt;/sup&gt; Observation-POI</td>
<td>FN, Observations and POIs transcribed, coded for cognitive demand, and finding of themes or patterns using Dedoose.</td>
</tr>
<tr>
<td>3. What is the cognitive complexity of the mathematical tasks and questions employed by the instructors during the instructional strategies?</td>
<td>SQ - 4 1&lt;sup&gt;st&lt;/sup&gt; POI 2&lt;sup&gt;nd&lt;/sup&gt; POI 3&lt;sup&gt;rd&lt;/sup&gt; POI</td>
<td>Statistical analysis of SQ – 4 using Qualtrics. POIs transcribed, coded for instructional strategies, and finding of themes or patterns using Dedoose.</td>
</tr>
<tr>
<td>4. What types of professional development do Missouri CC developmental mathematics instructors indicate is needed in order to successfully implement instructional strategies to promote active learning in their instruction?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: FN = Field Notes, POI = Post-Observation Interview, SQ = Survey Question

**Trustworthiness**

Trustworthiness is of critical importance in qualitative data analysis, allowing the researcher to be able to persuade the audience that the findings of the study are worth
paying attention to (Lincoln & Guba, 1985; Marshall & Rossman, 2011). I have addressed trustworthiness in several ways. To begin with, I have addressed the credibility of my study through persistent observation and triangulation of the data from the three case studies. From the data I collected from SQ – 1 and the classroom observations, I have identified the characteristics of the learning strategies that the case study participants have deemed to be most important and relevant when teaching developmental mathematics, thus addressing the persistent observation element. Finally, as I worked through my coding and analysis I collaborated with one of my peers to make sure the codes represented the data well (Saldana, 2009).

Additionally, as recommended by Saldana (2009), I asked a peer to code a sample of the transcripts to see if our interpretations of the coding would be similar. We each separately coded one page-length of transcript from each of the nine observations. The cognitive complexities of each of the tasks were coded; the cognitive complexities of the questions employed during the tasks were coded; and finally, the overall instructional strategy used during the implementation of each of the tasks was coded by each of us. After the analysis, I found that we coded within a similar accuracy of approximately 80%, thus aiding in the trustworthiness of the coding. Finally, I addressed trustworthiness through member checks (Lincoln & Guba, 1985). This occurred as I performed the post-observation interviews, when I asked the case study participants for clarification during the interview process if needed. Also, because I audio recorded the observations and interviews, I was able transcribe what the instructor said word for word without error. I had no difficulty hearing the voices of the instructors on the audio recordings because I had the instructors wear a microphone around their necks during the observations.
Role of the Researcher

In this study the role of the researcher could be described in a couple of ways. First, I assumed the role of the key instrument for gathering the data for this study (Creswell, 2007). While the Qualtrics survey tool was used to collect the quantitative data, I was the researcher who gathered the information on the observations and POI protocols for the qualitative data. I also transcribed all the observations and interviews, and entered these transcriptions into Dedoose for coding.

Second, when observing the instructors’ classes, I assumed the role of a non-participant observer (Mesa, 2010). As a non-participant observer, I only took field notes during the class I was observing and did not involve myself in any way, with either the instructor or the students, during the observation.

My background could influence how I interpreted the data that I gathered. In the case studies I worked with instructors who came from multiple backgrounds, with differing educational and career backgrounds than myself. My career experiences involve both Mechanical Engineering, and Mathematics and Science teaching. Within mathematics teaching, I have taught at the middle school/junior high level, at a tutoring center in a four-year college, and at a four-year research institution. These different experiences have allowed me to work with both genders and in varying positions. Because of my teaching experiences I do understand many of the challenges that mathematics teachers face, which helped me to relate to the developmental mathematics teachers I studied. Thus, I feel that I was able to share my experiences with the teachers I studied. Bott (2010) notes that it is important for qualitative researchers to have a relaxed dialogue with their research participants, “in order to preserve a sense of the researcher’s
own subjectivity within the process…and also towards the nurturing of relationship of mutual exchange” (p. 159). My experiences in teaching helped me to have a comfortable dialogue with mathematics teachers. However, I must remember my experience as a researcher in higher education might cause me to view developmental mathematics instruction through a different lens than those who actually work with these students. I needed to remember that these instructors may have other ideas concerning effective instructional strategies for developmental mathematics students, and so I needed to keep myself open to their views and experiences.
CHAPTER 4: ANALYSIS OF DATA AND RESULTS

This study sought to document the instructional strategies used by developmental mathematics instructors in Missouri’s public 2-year colleges to engage students in the learning process, the cognitive complexity of the instructional strategies, and the support needed by these instructors to engage their students in the learning process. Specifically, this study addressed the following research questions:

1. How do Missouri community college developmental mathematics instructors describe the instructional strategies they use to promote active learning?

2. What instructional strategies used to promote active learning, as recommended by AMATYC, do developmental mathematics instructors rate as important and indicate they employ in their classrooms?

3. What is the cognitive complexity of the mathematical tasks and questions employed by the instructors during the instructional strategies?

4. What types of professional development do Missouri community college developmental mathematics instructors indicate is needed in order to successfully implement instructional strategies to promote active learning in their instruction?

This chapter begins with a synopsis of the demographic data concerning the developmental mathematics instructors in Missouri. Next, information from the survey that aids in answering the research questions are given, which includes both qualitative and quantitative data. Finally, the qualitative data from the case studies will follow, which additionally aid to answer the research questions.

The research-based framework of instructional strategies to promote active learning in developmental mathematics as recommended by AMATYC (2006), was used
to inform the qualitative analyses of survey data, interview transcripts, and observation transcripts for this study (Table 1). Although several components of the AMATYC (2006) framework were confirmed by the analyses, new components related to instructional strategies implemented by developmental mathematics instructors in Missouri’s public 2-year colleges also emerged in the qualitative data.

*The Task Analysis Guide* was used to inform the qualitative analyses of the observation transcripts, for the cognitive complexity of the mathematical tasks used during the instructional strategies to promote active learning (Table 2). Additionally, the *Framework for Determining Cognitive Level of the Types of Questions Used in Mathematics Teaching* was used to inform the qualitative analyses of the observation transcripts, for the cognitive complexity of the questions used during the instructional strategies to promote active learning (Table 3). When appropriate, specific examples from the data sources will be used to support the findings.

Finally, this chapter also includes a final section reporting on the types of professional development Missouri community college developmental mathematics instructors indicate is needed in order for them to successfully implement instructional strategies to promote active learning in their instruction. Again, when appropriate, specific examples from the data sources will be used to support the findings. When a teacher is identified, pseudonyms (Table 18) will be used to ensure confidentiality of all subjects.

**Initiation of the Active Learning Survey**

The Active Learning Survey was sent to 494 developmental mathematics instructors across all 13 of Missouri’s 2-year public CCs after completion of IRB
approvals. The survey was open for approximately 2 weeks, over which I sent instructors a reminder after the first week, and on the next to last day to the closure of the survey. Of the 494 instructors contacted, 244 read the consent form (SQ – 1), with 185 consenting to continue the survey. Of the 185 participants who started the survey, 146 participants completed the entire survey, resulting in a 30% response rate of total completion. There were 185 partially completed surveys, resulting in a 37% response rate of partial completion.

**Demographic Information About the Developmental Mathematics Instructors**

The demographic survey questions began with survey question 10 and continued through question 15. The first question (SQ – 10) was whether the participant was considered full-time (FT) or part-time (PT). Of the 156 responses given, 66 (or 42%) indicated they were FT instructors, as opposed to the 90 (or 58%) who indicated they were PT or adjunct instructors.

In SQ – 11, participants were asked to select the types of institutions they have taught at. Of the 154 responses, 154 (or 100%) responded they had taught at the 2-year college level, 85 (or 55%) had also taught at the high school level, 63 (or 41%) had taught at the middle school/junior high level, 44 and 45 (or 29%) had taught at a four-year college and a four-year university respectively, and 23 (or 15%) had taught at the elementary school level. Those that had “other” teaching experiences explained it as teaching in an MBA Program, working with Cognitive Brain Therapy, Technical Training, Sylvan Learning, being a Math Consultant to a manufacturing company, teaching in the U.S. Army, and being a private tutor. Figure 3 shows the chart of the results from the 154 responses given by the participants.
Figure 3. Types of institutions Missouri developmental mathematics instructors have taught at.

In Table 8 one can see the breakdown of the institutions that Missouri developmental mathematics had previously taught at, cross-tabulated with their work status. More PT instructors taught Elementary School than FT with 70% as compared to 30%. Even though more PT instructors responded to the survey (58%) the numbers are still higher. Likewise, more PT instructors taught at the Middle School/Junior High level with 75% as compared to 25%; more PT taught at the High School level with 65% as compared to 35%; and more PT taught at the Two-Year College level with 61% as compared to 39%. Only at the Four-Year College do the numbers become comparable with PT at 61% and FT at 39%, which is closer to the numbers of the types responding to the survey. Those instructors having previously taught at Four-Year Institutions were more prevalent with FT at 56% as compared to 44% of PT instructors.
Table 8

*Types of Institutions Developmental Mathematics Instructors Have Taught At, Cross-Tabulated With Their Work Status*

<table>
<thead>
<tr>
<th>Type of Institution</th>
<th>Total</th>
<th>FT</th>
<th>PT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elementary School (Grades K – 5)</td>
<td>23</td>
<td>7</td>
<td>16</td>
</tr>
<tr>
<td>Middle School/Junior High (Grades 6 – 8)</td>
<td>63</td>
<td>16</td>
<td>47</td>
</tr>
<tr>
<td>High School (Grades 9 – 12)</td>
<td>85</td>
<td>30</td>
<td>55</td>
</tr>
<tr>
<td>Two-Year College</td>
<td>154</td>
<td>63</td>
<td>91</td>
</tr>
<tr>
<td>Four-Year College</td>
<td>44</td>
<td>17</td>
<td>27</td>
</tr>
<tr>
<td>Four-Year University</td>
<td>45</td>
<td>25</td>
<td>20</td>
</tr>
<tr>
<td>Other</td>
<td>13</td>
<td>7</td>
<td>6</td>
</tr>
</tbody>
</table>

The next survey question, (SQ – 12), asked participants which educational degrees they had completed. They were to select all the degrees that applied to them. There were 163 responses for Bachelor’s degrees, of which 57 responses and 56 responses, or approximately 35% for each, held a Bachelor in Mathematics and Bachelors in Mathematics Education. These accounted for 70% of the responses. The next largest category was a Bachelor’s in Education in some other non-mathematics education-related field (e.g. Physics Ed or Ed Tech) to which 24 participants (or 15%) accounted for (Figure 4). Thus, indicating approximately half of the instructors had some type of pedagogical training. The remaining 15% of the Bachelor’s degrees were comprised of those in a mathematics-related science field, mathematics-related business field, or other.

Information about participants Master’s and Doctoral degrees were also obtained in SQ – 12. Of the 163 responses, 49 (or 30%) of the participants had a Masters in Mathematics; 38 (or 23%) had as Masters in Mathematics Education; 32 (or 20%) had a Masters in Education in some other non-mathematics education-related field; 6 (or 3.6%)
had a Masters in a mathematics-related science (e.g. Physics, Chemistry, or Engineering); 7 (or 4%) had a Masters in a mathematics-related business field (e.g. Economics, Finance); 13 (or 8%) had a Masters in some field not directly listed in the survey; 3 (or 2%) had a Doctorate in Mathematics; and 3 (or 2%) had a Ph.D. or Ed.D. in Education or some non-mathematics education-related field (Figure 5). The remaining 7.4% of the Masters and Doctorate degrees were comprised of those in a statistics, mathematics-related science field, or other type of degree not listed in the survey.

*Figure 4.* Number of bachelors degrees completed by Missouri developmental mathematics instructors.
Figure 5. Number of masters and doctorate degrees completed by Missouri developmental mathematics instructors.
Table 9

*Degrees Completed by Missouri Developmental Mathematics Instructors Cross-Tabulated With Their Work Status*

<table>
<thead>
<tr>
<th>Type of Degree</th>
<th>Total</th>
<th>FT</th>
<th>PT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bachelors in Mathematics</td>
<td>57</td>
<td>31</td>
<td>26</td>
</tr>
<tr>
<td>Bachelors in Mathematics Education</td>
<td>56</td>
<td>20</td>
<td>36</td>
</tr>
<tr>
<td>Bachelors in Statistics</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Bachelors in Education or some other non-math education-related field (e.g. Physics Ed. or Ed. Tech)</td>
<td>24</td>
<td>6</td>
<td>18</td>
</tr>
<tr>
<td>Bachelors in a mathematics-related science (e.g. Physics, Chemistry, Engineering)</td>
<td>10</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>Bachelors in a mathematics-related business field (e.g. Economics, Finance)</td>
<td>4</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Bachelors in some field not directly listed here</td>
<td>12</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Masters in Mathematics</td>
<td>49</td>
<td>32</td>
<td>17</td>
</tr>
<tr>
<td>Masters in Mathematics Education</td>
<td>38</td>
<td>17</td>
<td>21</td>
</tr>
<tr>
<td>Masters in Statistics</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Masters in Education or some other non-math education-related field (e.g. Physics Ed. or Ed. Tech)</td>
<td>32</td>
<td>10</td>
<td>22</td>
</tr>
<tr>
<td>Masters in a mathematics-related science (e.g. Physics, Chemistry, Engineering)</td>
<td>6</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Masters in a mathematics-related business field (e.g. Economics, Finance)</td>
<td>7</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Masters in some field not directly listed here</td>
<td>13</td>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td>Ph.D. in Mathematics</td>
<td>3</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Ph.D. or Ed.D. in Mathematics Education</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Ph.D. or Ed.D. in Statistics</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Ph.D. or Ed.D. in Education or some other non-mathematics education-related field (e.g. Physics Ed. or Ed. Tech)</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Ph.D. in a mathematics-related science (e.g. Physics, Chemistry, Engineering)</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Ph.D. in a mathematics-related business field (e.g. Economics, Finance)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Other, please specify</td>
<td>8</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>
A cross-tabulation of the degrees completed by Missouri developmental mathematics instructors compared to their work status is given in Table 9. One can see that 31 FT as compared to 26 PT participants received a Bachelor’s in Mathematics, and 20 FT as compared to 36 PT participants received a Bachelor’s in Mathematics Education. Finally, 6 FT as compared to 18 PT received a Bachelor’s in Education in some other non-mathematics education-related field. This indicates that both FT and PT instructors had some pedagogical training during their Bachelor’s degrees. Likewise, 32 FT as compared to 17 PT participants received a Master’s in Mathematics; 17 FT as compared to 21 PT participants received a Master’s in Mathematics Education; and 10 FT as compared to 22 PT participants received a Master’s in Education in some other non-mathematics education-related field. Again, this indicates the high level of training with respect to pedagogy and mathematics, of the developmental mathematics instructors in Missouri who are either FT or PT.

The final demographic question in the survey, SQ – 13, asked the instructors which professional societies they were currently a member of. Table 10 shows the results from this question. The largest organization instructors indicated they were a member of, was MCCA (Missouri Community College Association) with 40 participants, followed by NCTM with 30 participants, MOMATYC (Missouri Mathematical Association of Two Year Colleges) with 26 participants, and AMATYC with 24 participants. Additionally, participants were given the opportunity to list other professional societies they were members of. The top organizations listed were MRADE (Midwest Regional Association for Developmental Education) with 6 members; NADE (National Association of Developmental Education) with 5 members; MEGSL (Math Educators of
Greater Saint Louis) with 5 members; and MO-DEC (Missouri Developmental Education Consortium) with 3 members. What is interesting is the larger number of FT instructors that belonged to professional societies as opposed to PT instructors, with the exception of MCTM (Missouri Council of Teachers of Mathematics). This finding will be addressed in Chapter 5.

Table 10

Membership Statuses to Professional Societies of Developmental Mathematics

<table>
<thead>
<tr>
<th>Professional Society</th>
<th>Number of Participants Indicating Membership</th>
<th>Number of Full-Time Instructors</th>
<th>Number of Part-Time Instructors</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCTM</td>
<td>30</td>
<td>19</td>
<td>11</td>
</tr>
<tr>
<td>MCTM</td>
<td>15</td>
<td>4</td>
<td>11</td>
</tr>
<tr>
<td>AMATYC</td>
<td>24</td>
<td>23</td>
<td>1</td>
</tr>
<tr>
<td>MOMATYC</td>
<td>26</td>
<td>23</td>
<td>3</td>
</tr>
<tr>
<td>AMS</td>
<td>6</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>MAA</td>
<td>10</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>MCCA</td>
<td>40</td>
<td>38</td>
<td>2</td>
</tr>
</tbody>
</table>

AMATYC – American Mathematics Association of Two-Year Colleges
AMS – American Mathematical Society
MAA – Mathematical Association of America
MCCA – Missouri Community College Association
MCTM – Missouri Council of Teachers of Mathematics
MOMATYC – Missouri Mathematics Association of Two-Year Colleges
NCTM – National Council of Teachers of Mathematics

Instructor Descriptions of Strategies for Engaging Students

Prior to answering the demographic questions on the survey, instructors answered the survey questions that aided in satisfying the research questions for this study. Thus, after they consented to participate in the survey, the next survey question SQ – 2, asked the instructors to describe the two strategies they felt were most effective for engaging their students in the learning process in developmental mathematics. In the following
table, the most common codes of the instructional strategies are given, as well as examples of how instructors described these strategies (Table 11). The codes included in this data set were mentioned approximately at least 4% of the time or more by instructors.

In several of the primary codes, there were secondary codes that described the primary codes. In the 9 most commonly mentioned instructional strategies (primary codes) listed in Table 11, 4 of these had secondary codes that stood out within these strategies. The examples that are given by the instructors will showcase the secondary codes within these strategies.

Within the “Collaborative/Cooperative Learning” primary code, the secondary codes that were most prevalent amongst instructors were solving textbook problems (33%), explaining the problem (29%), and discussing the solution (28%). In the primary codes of “Use of Textbook Problems,” “Enthusiasm/Encouragement,” and “Computer-Assisted Technology” there were no secondary codes.

Next, within the “Question-Posing” primary code, the secondary code that was most prevalent amongst instructors was the use of guiding questions (81%) to lead students to the solutions of problems, with engaging students in activities to develop conceptual understanding (19%) following up. The primary codes of “One-on-One Interaction” and “Real-World Problems” did not have secondary codes.

With the primary code of “Interactive Lecturing,” there were several prominent secondary codes: the use of note packets during the lecture being the most prevalent (39%), having students comparing processes (28%), and finally solving the problem using alternative methods (22%). Lastly, for the primary code of Writing, the secondary
code that was most prevalent was having students taking notes during class (80%), with writing about homework (18%).
Table 11

**Instructor Descriptions of Strategies for Engaging Students in the Learning Process**

<table>
<thead>
<tr>
<th>Code</th>
<th>Frequency</th>
<th>%</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collaborative/Cooperative Learning</td>
<td>60</td>
<td>21.2</td>
<td>“I believe in using group work to facilitate community, proper use of math vocabulary, and fun while learning something new. Group work can be used many different ways. Groups can be given a challenging problem to tackle together, guided through an exploration of a new topic, or simply given a few exercises to work on together.”</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>“Group work and have them collaborate on how to work the problems with no teacher interaction. This forces the students to work together. This helps the students that don’t understand get a different perspective on how to work a problem from their peer.”</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>“Asking students to work together, check in-class problems with each other, solve work as a group.”</td>
</tr>
<tr>
<td>Use of Textbook Problems</td>
<td>59</td>
<td>20.9</td>
<td>“Even when I did a lecture class, I encouraged student participation through question and answer. I also would put a problem up and wait for every student to find the answer. At that point we would then work through it on the board.”</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>“Participation in class that involves students going to the board and doing problems.”</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>“Getting them to explain to me step by step what the process is for working a problem.”</td>
</tr>
<tr>
<td>Method</td>
<td>Score</td>
<td>Rank</td>
<td>Quote</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-------</td>
<td>------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Enthusiasm/Encouragement</td>
<td>32</td>
<td>11.3</td>
<td>“To teach a developmental math class, you need to be understanding and very patient. All students come from a different math background and it doesn’t serve the students to judge them by what they don’t know. I encourage all my students to participate during my lecture.”</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>“Another effective strategy is simply showing enthusiasm for the material. I get excited about concepts when we start the section and laugh at me for it, but it warms them up to what we’re starting. Making it comfortable and fun in the classroom through simple conversation makes students feel like they can open up more, ask questions, and not be rejected. This is huge in making sure students are really a part of the class and the learning process.”</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>“Develop a classroom environment where students are encouraged and feel safe to make guesses, ask questions, and just try what feels right. The process of building this environment is complex, starts from day one and is cultivated throughout the semester. A lot of students in math classes have developed a very strong hopelessness over years of never really understanding. If this is not being addressed, it doesn’t matter how great you teach the actual material.”</td>
</tr>
<tr>
<td>Computer-Assisted Technology</td>
<td>30</td>
<td>10.6</td>
<td>“Encouraging students to use all aspects of MyMathLab.”</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>“We use a computer enhanced software system that provides them with immediate feedback and mastery learning.”</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>“Utilizing ALEKS to practice until achieving mastery of the objective.”</td>
</tr>
</tbody>
</table>
### Question-Posing

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>9.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>“As I am working out an example on the board, I will ask the class to tell me what to do next.”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>“Put other examples on the board and go around the room having each student tell me orally how to start the problem, what the next step is, what rule allows them to do what they are doing, etc., until they have completed the problem.”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>“Having the students talk me through the process.”</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### One-on-One

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>8.8</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Take time EVERY class to sit down with EVERY student, to gauge their progress, help with any mathematical or time-management issues, and encourage them to continue. I e-mail every student at least once or twice per week.”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>“One-on-one time for questions and problem explanation during practice work or homework.”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>“Spending time one-on-one with the students going over their work.”</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Real-World Problems

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>7.4</th>
</tr>
</thead>
<tbody>
<tr>
<td>“The most effective strategy I have found is to apply the math to authentic situations. Everyone hears the question, “When will I ever use this?” and I continue to hear it in my Elementary Algebra class. When you actually have a solid answer and examples for when they use it in life they are more eager to understand and master the concept. They realize it is not just busy work.”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>“When I am giving examples in class, I can use my knowledge of their interests to relate what we are covering with an analogy of something that they enjoy and/or understand. They generally want to know about the bigger picture and it helps them when you tell them that they are learning the “nuts and bolts” of mathematics when they are a mechanic by trade.”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>“Real-life examples of the math, they seem to remember and understand it better.”</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Interactive Lecturing | 19 | 6.7 | “Distributing ‘incomplete’ study notes for students to use as we discuss topics/problems together in class.”

“Dry erase boards to use for class problems – so that the instructor can see which students are learning the new process and where the problem area(s) might be.”

“Be willing to answer their questions and provide alternate strategies to those shown in the text.” |
|----------------------|----|-----|----------------------------------|
| Writing              | 11 | 3.9 | “Each student must be actively taking notes during the lecture. I have them keep a math notebook with notes and handouts.”

“I require students to look over class notes, pick out the most important point, examples, definitions, or procedures, and write them down again in a packet.”

“Computer-assisted math class, the students are required to keep a notebook of their notes, homework, and quizzes as they work through their modules.” |
| Total                | 283| 100.0 |
Rating of Recommended AMATYC Instructional Strategies

The research-based framework of instructional strategies to promote active learning in developmental mathematics (AMATYC, 2006) provided the foundation for survey question 3 (Table 1). In SQ – 3, instructors were asked to rate how important they felt the following teaching strategies were for use in a developmental mathematics classroom. The Qualtrics program scaled the items, rating “Extremely Important” as 1 to “Not Important at All” as 5. Table 12 shows how many instructors responded to each item, how they rated each item, and the Mean of each item.

The top two choices rated close to Extremely Important by instructors were, “Ask questions to guide students to solutions of problems” with a Mean of 1.46 and “Present examples that lead to patterns, which form the basis of mathematical rules” with a Mean of 1.55. Followed by the next three choices, “Respond to any answer given (right or wrong) and discuss the logical ramifications of trying to solve the problem using alternative methods” with a Mean of 1.70; “Engage students in activities that lead them to develop conceptual understandings” with a Mean of 1.85; and “Use student answers to guide classroom discussion” with a Mean of 1.93. These responses are highlighted in yellow in Table 12.

Two responses rated close to Very Important for all instructors. These included “Encourage students to take notes and/or keep track of important mathematics ideas and problem statements by writing a checklist on the board or disseminating a fact sheet” with a Mean of 2.27; and “Provide pairs or small groups of students the opportunity to work together to explain a problem, interpret a graph, review another student’s work,
discuss the correct solution, or engage in a project” with a Mean of 2.36. These are highlighted in peach in Table 12.

The least important responses according to the instructors were those dealing with writing in mathematics, getting together outside of class, and technology. The response “Ask students to write questions that require explanations” had a Mean of 3.09; “Ask students to work in pairs on a homework problem before class begins” had a Mean of 3.18; “Include a writing component in homework, student projects, investigation, and explorations of mathematical concepts” had a Mean of 3.24; “Ask students at the beginning of class to write about what they learned from doing the homework” had a Mean of 3.60; and “Assign Internet group project (in or out of class) or technology activities had a Mean of 3.61.
Table 12

Rating of the Recommended AMATYC Instructional Strategies by Missouri Developmental Mathematics Instructors

<table>
<thead>
<tr>
<th>#</th>
<th>Question</th>
<th>Extremely Important (1)</th>
<th>Very Important (2)</th>
<th>Important (3)</th>
<th>Not Very Important (4)</th>
<th>Not Important At All (5)</th>
<th>Total Responses</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Provide pairs or small groups of students the opportunity to work together to explain a problem, interpret a graph, review another student’s work, discuss the correct solution, or engage in a project.</td>
<td>46</td>
<td>58</td>
<td>51</td>
<td>25</td>
<td>4</td>
<td>184</td>
<td>2.36</td>
</tr>
<tr>
<td>2</td>
<td>Assign Internet group projects (in or out of class) or technology activities.</td>
<td>10</td>
<td>19</td>
<td>39</td>
<td>81</td>
<td>35</td>
<td>184</td>
<td>3.61</td>
</tr>
<tr>
<td>3</td>
<td>Ask students to work in pairs on a homework problem before class begins.</td>
<td>6</td>
<td>35</td>
<td>72</td>
<td>58</td>
<td>11</td>
<td>182</td>
<td>3.18</td>
</tr>
<tr>
<td>4</td>
<td>Use student answers to guide classroom discussion.</td>
<td>66</td>
<td>73</td>
<td>37</td>
<td>7</td>
<td>1</td>
<td>184</td>
<td>1.93</td>
</tr>
<tr>
<td>5</td>
<td>Present examples that lead to patterns, which form the basis of mathematical rules.</td>
<td>102</td>
<td>64</td>
<td>16</td>
<td>2</td>
<td>0</td>
<td>184</td>
<td>1.55</td>
</tr>
<tr>
<td>6</td>
<td>Respond to any answer given (right or wrong) and discuss the logical ramifications of trying to solve the problem using alternative methods.</td>
<td>88</td>
<td>67</td>
<td>26</td>
<td>3</td>
<td>0</td>
<td>184</td>
<td>1.70</td>
</tr>
<tr>
<td>7</td>
<td>Ask questions to guide students to solutions of problems.</td>
<td>118</td>
<td>49</td>
<td>16</td>
<td>1</td>
<td>0</td>
<td>184</td>
<td>1.46</td>
</tr>
<tr>
<td>8</td>
<td>Engage students in activities that lead them to develop conceptual understandings.</td>
<td>81</td>
<td>57</td>
<td>40</td>
<td>5</td>
<td>1</td>
<td>184</td>
<td>1.85</td>
</tr>
<tr>
<td>9</td>
<td>Ask students to write questions that require explanations.</td>
<td>16</td>
<td>28</td>
<td>66</td>
<td>71</td>
<td>3</td>
<td>184</td>
<td>3.09</td>
</tr>
<tr>
<td>10</td>
<td>Ask students at the beginning of class to write about what they learned from doing the homework.</td>
<td>5</td>
<td>8</td>
<td>64</td>
<td>84</td>
<td>22</td>
<td>183</td>
<td>3.60</td>
</tr>
<tr>
<td>11</td>
<td>Encourage students to take notes and/or keep track of important mathematics ideas and problem statements by writing a checklist on the board or disseminating a fact sheet.</td>
<td>58</td>
<td>49</td>
<td>51</td>
<td>22</td>
<td>4</td>
<td>184</td>
<td>2.27</td>
</tr>
<tr>
<td>12</td>
<td>Include a writing component in homework, student projects, investigation, and explorations of mathematical concepts.</td>
<td>12</td>
<td>23</td>
<td>74</td>
<td>59</td>
<td>16</td>
<td>184</td>
<td>3.24</td>
</tr>
</tbody>
</table>

*Rows highlighted in yellow rated between extremely to very important; and those in peach rated between very to important for instructors.
The coding of the instructional strategies corresponded with the Table 1. Thus, Questions 1 to 3 were coded as Collaborative/Cooperative Learning strategies. Both questions 4 and 5 fell under Discovery-Based Learning. Question 6 was coded as Interactive Lecturing. Both questions 7 and 8 were coded as Question-Posing. Finally, questions 9 through 12 were coded as Writing strategies. This information will be helpful in the summary discussion when I am comparing the instructional strategies that teachers individually described, then rated the recommended AMATYC (2006) strategies, and lastly those strategies that I observed actually used by instructors in the classroom.

Implementation of Recommended AMATYC Instructional Strategies

As in SQ – 3, the research-based framework of instructional strategies to promote active learning in developmental mathematics as recommended by AMATYC (2006), provided the foundation for SQ – 4 (Table 1). In SQ – 4, instructors were asked to describe their implementation of the following teaching strategies for use in a developmental mathematics classroom. The instructors were also asked to indicate if they felt they needed help implementing any of the instructional strategies so that I could make a recommendation in this study about professional development needs. Participants could mark multiple times within a question, so a Mean was not calculated for these responses, just the total number of responses (Table 13).

These responses mirrored very much the responses of SQ – 3. The top five responses on SQ – 3 that rated between 1.5 and 2 (between Extremely Important and Important) are the same responses on SQ – 4 for which instructors indicated they “Have Implemented This Strategy.” Additionally, Question #1 and #11, which were rated between 2.0 and 2.5 (Very Important and Important), were those same responses for
which instructors indicated they “Have Implemented This Strategy.” Responses to
Questions #3, #9, and #12 were all over the board, meaning they had implemented the
strategy, they had not implemented it, and they were not interested in implementing the
strategy. The instructional strategy suggesting to “Assign Internet group projects (in or
out of class) or technology activities” was selected as one in which most instructors were
not interested in implementing.

Given the option to select the instructional strategies for which help was needed
for implementation, only two stood out. Eight instructors selected “Engage activities that
lead them to develop conceptual understandings” and seven selected “Ask students to
write questions that require explanations,” which was only 5% of the total responses for
each of the questions.
<table>
<thead>
<tr>
<th>#</th>
<th>Question</th>
<th>Have Implemented This Strategy</th>
<th>Have Not Implemented</th>
<th>Plan to Implement in the Future</th>
<th>Not Interested In Implementing</th>
<th>Need Help Implementing</th>
<th>Total Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Provide pairs or small groups of students the opportunity to work together to explain a problem, interpret a graph, review another student’s work, discuss the correct solution, or engage in a project.</td>
<td>122</td>
<td>18</td>
<td>12</td>
<td>13</td>
<td>1</td>
<td>166</td>
</tr>
<tr>
<td>2</td>
<td>Assign Internet group projects (in or out of class) or technology activities.</td>
<td>41</td>
<td>45</td>
<td>5</td>
<td>73</td>
<td>4</td>
<td>168</td>
</tr>
<tr>
<td>3</td>
<td>Ask students to work in pairs on a homework problem before class begins.</td>
<td>63</td>
<td>52</td>
<td>17</td>
<td>32</td>
<td>1</td>
<td>165</td>
</tr>
<tr>
<td>4</td>
<td>Use student answers to guide classroom discussion.</td>
<td>150</td>
<td>8</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>165</td>
</tr>
<tr>
<td>5</td>
<td>Present examples that lead to patterns, which form the basis of mathematical rules.</td>
<td>153</td>
<td>7</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>165</td>
</tr>
<tr>
<td>6</td>
<td>Respond to any answer given (right or wrong) and discuss the logical ramifications of trying to solve the problem using alternative methods.</td>
<td>156</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>165</td>
</tr>
<tr>
<td>7</td>
<td>Ask questions to guide students to solutions of problems.</td>
<td>159</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td>165</td>
</tr>
<tr>
<td>8</td>
<td>Engage students in activities that lead them to develop conceptual understandings.</td>
<td>117</td>
<td>23</td>
<td>13</td>
<td>8</td>
<td>8</td>
<td>169</td>
</tr>
<tr>
<td>9</td>
<td>Ask students to write questions that require explanations.</td>
<td>47</td>
<td>63</td>
<td>17</td>
<td>35</td>
<td>7</td>
<td>169</td>
</tr>
<tr>
<td>10</td>
<td>Ask students at the beginning of class to write about what they learned from doing the homework.</td>
<td>28</td>
<td>73</td>
<td>11</td>
<td>57</td>
<td>2</td>
<td>171</td>
</tr>
<tr>
<td>11</td>
<td>Encourage students to take notes and/or keep track of important mathematics ideas and problem statements by writing a checklist on the board or disseminating a fact sheet.</td>
<td>124</td>
<td>22</td>
<td>5</td>
<td>12</td>
<td>1</td>
<td>164</td>
</tr>
<tr>
<td>12</td>
<td>Include a writing component in homework, student projects, investigation, and explorations of mathematical concepts.</td>
<td>67</td>
<td>45</td>
<td>13</td>
<td>42</td>
<td>5</td>
<td>172</td>
</tr>
</tbody>
</table>
Follow-Up Survey Questions Concerning the Implementation

The next four survey questions SQ – 5 through SQ – 8, asked participants which of the strategies listed in Table 13 they would:

- Use to engage students in the learning process when teaching a developmental mathematics course? Please explain. (SQ – 5)
- NOT use to engage students in the learning process when teaching a developmental mathematics course? Please explain. (SQ – 6)
- Use to engage students in the learning process when teaching a credit-bearing college-level mathematics course (e.g. College Algebra, Statistics, or above)? Please explain. (SQ – 7)
- NOT use to engage students in the learning process when teaching a credit-bearing college-level mathematics course (e.g. College Algebra, Statistics, or above)? Please explain. (SQ – 8)

Although these questions may seem redundant to SQ – 4, the explanations they provided for SQ – 5 and SQ – 6 are very helpful in understanding why some of these strategies are useful or not useful for developmental mathematics instructors. Additionally, I wanted to know in SQ – 7 and SQ – 8 if the respondents used different instructional strategies to teach students taking higher-level mathematics courses.

The responses for SQ – 5 and SQ – 6 are paired up very similarly with SQ – 4, with even many participants stating, see those that I checked as “Have Implemented This Strategy” and see those that I have checked as “Not Interested in Implementing.” Of the 147 responses towards the instructional strategies given to use when teaching a developmental mathematics course, 20% of the participants chose #1, 13% chose #4,
12% chose #5, 10% chose #6 and #7, and 7% chose #8 and #11. (Nine percent chose “All” of the strategies and the rest of the 12% chose the other strategies.) The top strategies instructors chose to use in developmental mathematics classes were: provide pairs or small groups of students the opportunity to work together; use student answers to guide classroom discussion; and present examples that lead to patterns. See Table 14 for those strategies instructors would use in developmental mathematics classes and their comments about why the strategies are so important.

As for the instructional strategies listed in Table 15 that developmental mathematics instructors would NOT use to engage students in the learning process, 48% chose #2, 21% chose #12, 10% chose #10, 7% chose #9 and #3, leaving 7% with the other strategies. The least important strategies were: assigning Internet group projects (in or out of class) or technology activities; include a writing component in homework; and ask students at the beginning of the class to write about what they learned from doing the homework. As previously mentioned, this mirrored the responses to SQ – 4. See Table 15 for those strategies instructors would NOT use in developmental mathematics classes and their comments as to why.

Looking at what instructional strategies instructors would use (SQ – 7) and would NOT use (SQ – 8) to engage students in the learning process when teaching a credit-bearing college-level mathematics course, the responses were very similar, yet a couple of changes were seen. For SQ – 7, one-third of the responses (33%), the instructors said they would use the same strategies as in a developmental mathematics course, as well as 9% choosing “all” of the strategies. Additionally, 17% chose #1, 10% chose #7, 6% chose #12, 5% chose #4, #5, and #8, leaving 10% choosing the other strategies. Thus,
strategy #6 was not as popular (responding to any answer given) and #12 was chosen more (the writing component in homework). See Table 16 for those strategies instructors would use in credit-bearing college-level mathematics courses and their comments as to why the strategies are important.

For SQ – 8, again instructors were very similar in their answers for strategies they would NOT use in credit-bearing college-level mathematics courses to those they would not use in developmental mathematics courses. A large percentage, 41%, still chose #2; a larger percentage, 22% chose #10; a smaller percentage, 12% chose #12; 7% chose #9; 7% chose #11; 5% chose #3; leaving 6% choosing the other strategies. Thus, the same least important strategies were given for those in credit-bearing college-level mathematics courses as given in the previous paragraph. See Table 17 for those strategies instructors would NOT use in credit-bearing college-level mathematics courses and their comments as to why.
<table>
<thead>
<tr>
<th>#</th>
<th>Instructional Strategy (% choosing this strategy)</th>
<th>Respondent Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Provide pairs or small groups of students the opportunity to work together to explain a problem, interpret a graph, review another student’s work, discuss the correct solution, or engage in a project. (20%)</td>
<td>“I think providing pairs or small groups to explain a problem works well. They get to see how others are attempting to do the problem and gives them the opportunity to share their process with someone else. Being able to verbalize the mathematics is a major step to understanding mathematics.”</td>
</tr>
<tr>
<td>4</td>
<td>Use student answers to guide classroom discussion. (13%)</td>
<td>“When students ask questions or are giving answers to questions in class, this is helpful for the teacher to evaluate the understanding of the students. Those answers can then be used to give more examples or ask questions that can lead to better understanding for the students.”</td>
</tr>
<tr>
<td>5</td>
<td>Present examples that lead to patterns, which form the basis of mathematical rules. (12%)</td>
<td>“I use this strategy, because this way they will start to see that math is about patterns and not rules. Rules come from patterns, not the other way around.”</td>
</tr>
<tr>
<td>6</td>
<td>Respond to any answer given (right or wrong) and discuss the logical ramifications of trying to solve the problem using alternative methods. (10%)</td>
<td>“This works well even if the answer is wrong. It often leads into a class discussion of proper techniques and reason for why the change. Most of the time, by the end, the whole class has their light bulbs going off and their confidence raising.”</td>
</tr>
<tr>
<td>7</td>
<td>Ask questions to guide students to solutions of problems. (10%)</td>
<td>“I feel that the most important skill you can teach your students (in any class) is to question what they are doing and why they are doing it.”</td>
</tr>
<tr>
<td>8</td>
<td>Engage students in activities that lead them to develop conceptual understandings. (7%)</td>
<td>“Engage students that lead them to develop conceptual understandings because if a student develops the conceptual understand they have learned instead of memorized a process.”</td>
</tr>
<tr>
<td></td>
<td>Encourage students to take notes and/or keep track of important mathematics ideas and problem statements by writing a checklist on the board or disseminating a fact sheet. (7%)</td>
<td></td>
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<tr>
<td>---</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td></td>
<td>“I provide what I call ‘guided’ notes to the students. This is simply a list of definitions that we go over in class and problems from out of the textbook or software that we do together. I have found that the students oftentimes could ’t or didn’t have the correct steps or notes in their notebook when they were allowed to write their own notes. Perhaps this was because they couldn’t keep up with the note taking or didn’t know how to take notes. By providing them with ‘guided’ notes, they have a better chance of having the correct information.”</td>
<td></td>
</tr>
</tbody>
</table>
### Table 15

*Explanations for NOT Wanting to Use Selected Strategies in Developmental Mathematics*

<table>
<thead>
<tr>
<th>#</th>
<th>Instructional Strategy (% choosing this strategy)</th>
<th>Respondent Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Assign Internet group projects (in or out of class) or technology activities. (48%)</td>
<td>“I would not use Internet group projects for developmental mathematics for several reasons: 1) most of my students do not have reliable Internet access due to their economic situations; 2) I teach night classes and most of my students are non-traditional students with full-time employment during the day – they are sometimes not internet-proficient, nor do they have extra time to coordinate schedules for group work outside of class; and 3) I have found in the past that Internet group projects are just a copy-paste exercise in plagiarism from other websites – I don’t like awarding zero credit due to cheating, inadvertent or otherwise.”</td>
</tr>
</tbody>
</table>
| 3  | Ask students to work in pairs on a homework problem before class begins. (7%) | “Too many students have so many outside conflicts that it is too complicated to get them to work on problems outside of class at the developmental level.”

“*I wouldn’t ask students to work on a problem together before class begins that would require them to arrive and work before the start of class and before the previous class had a chance to leave the room.*” |
| 9  | Ask students to write questions that require explanations. (7%) | “From past experience, I have found that the students tend to write questions that are at or below their own level of competency. My goal, at least as I see it, is to provide a level of rigor that forces student thinking to go beyond their current comfort zone.” |
| 10 | Ask students at the beginning of the class to write about what they learned from doing the homework. | “I find little to no value in this exercise. Students at this level of math often don’t truly see what they have learned from their homework. I try to link each and every section/topic to one another so that students do see the value of what they learned. Often I’ll ask students in class, ‘How does this connect with what we did last class session?’ This is more pertinent than, ‘What did you learn from doing homework?’” |
| 12 | Include a writing component in homework, student projects, investigation and explorations of mathematical concepts. | “I do not emphasize a writing component in the learning process. There are enough students for whom writing is itself a major stumbling block, that I choose not to add that burden to the students’ math anxiety and low level of confidence in their mathematical abilities.”

“I would probably not use much of a writing component in my developmental classes. Many of the students in these classes are also in developmental reading and writing. A writing component would most likely be frustrating since they struggle in that area also.” |
Table 16

*Explanations for Using Selected Strategies in Credit-Bearing College-Level Mathematics Courses*

<table>
<thead>
<tr>
<th>#</th>
<th>Instructional Strategy (Number of respondents choosing this strategy)</th>
<th>Respondent Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Provide pairs or small groups of students the opportunity to work together to explain a problem, interpret a graph, review another student’s work, discuss the correct solution, or engage in a project. (17%)</td>
<td>“This allows students to catch other learners’ errors as well as their own. This also helps the learner work in teams, preparing them for the real world.” “At the college algebra level I feel that small groups and cooperative learning would be much more effectively implemented. At this level students have more of a common level of capability and determination. Group work would be effective when it can be done in a more advanced setting.”</td>
</tr>
<tr>
<td>4</td>
<td>Use student answers to guide classroom discussion. (5%)</td>
<td>“I would use pairs to work on problems and allow students to explain their thinking/strategy. This provides solutions and discussion (of correct or incorrect answers) for the class. I guide their exploration with key questions designed for student discovery.”</td>
</tr>
<tr>
<td>5</td>
<td>Present examples that lead to patterns, which form the basis of mathematical rules. (5%)</td>
<td>“Mathematics is logic. It is important for the students to be shown WHY something happens or let them investigate it so that they make connections and can add meaning to the lesson.” “I feel in upper level courses the students need to be developing a set of rules so they can learn to apply math skills to problems outside the book.”</td>
</tr>
<tr>
<td></td>
<td>Question</td>
<td>Response</td>
</tr>
<tr>
<td>---</td>
<td>-----------</td>
<td>----------</td>
</tr>
</tbody>
</table>
| 7 | Ask questions to guide students to solutions of problems. | “I feel the most important skill you can teach your students (in any class) is to question what they are doing and why they are doing it.”  
“I believe that asking students questions and leading them to the solutions is a good method for general classroom teaching. It engages most students in the process, and allows me to go slow enough, so if there are questions about a step, I can answer it at that time.” |
| 8 | Engage students in activities that lead them to develop conceptual understandings. | “The higher the level of math, the more conceptual. Students taking developmental math are usually just trying to get their math credit to complete their degree. They may or may not use much math in their actual field of study. Upper level math students are much more likely to be using math in their field of study, i.e. pre-engineering or math majors. The will need to understand the concepts.”  
“I probably would focus more on conceptual learning, explaining and application in higher-level courses. My goal is to improve their critical thinking and problem solving skills.” |
| 12 | Include a writing component in homework, student projects, investigation and explorations or mathematical concepts. | “I would definitely incorporate some type of writing component where the student would be required to describe a process of what they have learned.”  
“I think it is important to assess a student’s conceptual understanding of how they arrived at their answer… it is also important to force the student to try to put their ideas into words.” |
Table 17

*Explanations for NOT Wanting to Use Selected Strategies in Credit-Bearing College-Level Mathematics Courses*

<table>
<thead>
<tr>
<th>#</th>
<th>Instructional Strategy (% choosing this strategy)</th>
<th>Respondent Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Assign Internet group projects (in or out of class) or technology activities.</td>
<td>“I would still not assign projects in a college level class (but for different reasons than the developmental class). My experience is that one person dominates the project and the other students go with the grade. It doesn’t work out for most involved.”</td>
</tr>
<tr>
<td></td>
<td></td>
<td>“This would be a good thing to do, because most classes don’t have the extra time to do group projects and cover the materials needed.”</td>
</tr>
<tr>
<td></td>
<td></td>
<td>“Group activities outside of class – extremely difficult for working adults to coordinate schedules.”</td>
</tr>
<tr>
<td>3</td>
<td>Ask students to work in pairs on a homework problem before class begins.</td>
<td>“Most of my students can barely get to class on time, much less early.”</td>
</tr>
<tr>
<td>9</td>
<td>Ask students to write questions that require explanations.</td>
<td>“Sometimes it is hard for the student to know if they know how to solve the math problem, let alone how to write questions about what they do not know about how to work the problem. This is good in theory, but I have had few that would take the time to do this or could do this.”</td>
</tr>
<tr>
<td></td>
<td>Suggestion</td>
<td>Quote</td>
</tr>
<tr>
<td>---</td>
<td>----------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>10</td>
<td>Ask students at the beginning of the class to write about what they learned from doing the homework.</td>
<td>“I think asking students to write summaries on what they have interpreted sometimes leads them to learn ‘wrong’ information. It is harder to unlearn something than to learn it correctly in the first place.”&lt;br&gt;“While it provides reflection upon their homework they have done, I don’t feel it is effective to helping them learn the material.”&lt;br&gt;“A lot of time the students will not know what they are going to use it for and this is only encouraging them to think negatively about the importance of math.”</td>
</tr>
<tr>
<td>11</td>
<td>Encourage students to take notes and/or keep track of important mathematics ideas and problem statements by writing a checklist on the board or disseminating a fact sheet.</td>
<td>“I would not ask students to write a checklist. It seems to stop the thinking process and move it back into learning just algorithms.”&lt;br&gt;“The note taking at this level – at this level, students don’t need to be rewarded for taking notes. This is a skill that they need to develop without the reward of classroom points.”</td>
</tr>
<tr>
<td>12</td>
<td>Include a writing component in homework, student projects, investigation and explorations of mathematical concepts.</td>
<td>“I understand the need to put thoughts to paper or be able to describe their thought process but I don’t think students get out of it what is desired. Most writing assignments built into the math class come across as busy work.”</td>
</tr>
</tbody>
</table>
Case Studies

As previously stated, each of the three participants selected for the case studies were chosen using the following criteria:

1. How participants described the instructional strategies they used to engage students in the learning process, rated the importance of, and implemented various instructional strategies, through survey questions 1, 2, and 3.

2. The amount of allotted time for the developmental mathematics courses the participants taught.

3. I selected instructors who taught different types of developmental mathematics courses.

4. I selected instructors based on the time during the day, as well as the time during the week they taught.

5. The proximity of the community college of each participant.

Thirty-one of the respondents gave permission in the survey for me to contact them for three observations and interviews, in order to complete the case study portion of this research study. In Table 18, pseudonyms are given for the three female instructors who were observed in the case studies, along with: their highest level of degree attained, the total number of years each instructor has taught at any education level, the total number of years each instructor has taught developmental mathematics, the types of professional associations each instructor is currently a member of, and the population classification of the 2-year college each instructor is currently teaching at, along with the approximate location in Missouri.
Table 18

Description of Participants Involved in the Case Studies

<table>
<thead>
<tr>
<th>Pseudonym of Full-Time Instructor</th>
<th>Highest Level of Degree</th>
<th>Total Number of Years Teaching</th>
<th>Number of Years Teaching Developmental Mathematics</th>
<th>Professional Associations Currently a Member of</th>
<th>Two-Year College Population Classification &amp; Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Professor Smith</td>
<td>M.Ed.</td>
<td>34</td>
<td>26</td>
<td>NCTM, AMATYC, AMS, MAA, MCCA</td>
<td>Rural – Central Missouri</td>
</tr>
<tr>
<td>Professor Lily</td>
<td>M.Ed.</td>
<td>15</td>
<td>9</td>
<td>NCTM, MCCA</td>
<td>Rural – East Central Missouri</td>
</tr>
<tr>
<td>Professor Buster</td>
<td>M.Ed.</td>
<td>24</td>
<td>18</td>
<td>NCTM, MCTM, AMATYC, MOMATYC, MAA, MCCA</td>
<td>Urban – East Missouri</td>
</tr>
</tbody>
</table>

Each instructor was observed three times followed by a post-observation interview, approximately every 2 weeks from mid-October to mid-November. At this point in the semester the routine of the classes were well established, but it was not at the point of the end of the semester where the instructors were in a time crunch to get the final content in or reviewing for the final. I also avoided visiting the classes on days that quizzes were given.

**Active Learning Instructional Strategies Implemented by Instructors**

In this section I will discuss how the instructors who participated in the case study answered their surveys. Next, I will explain how the instructors actually employed instructional strategies in their classrooms to engage students in the learning process. Finally, I will discuss how the instructors described their methods in the post-observation interviews. Each case will be presented one at a time.
**Professor Smith**

Prof. Smith was selected to participate in the case study for the following reasons: she indicated a higher use of instructional strategies to promote active learning on the survey; taught a 1 hour 15 min. class on a day that I was also able to make the trip to visit Prof. Lily; taught a Fundamentals of Algebra (Prior to Intermediate Algebra); and was within 1 hour of Columbia.

**Survey Response.** In the survey Prof. Smith described two instructional strategies for engaging students in the learning process as:

1) Asking students to work together, checking in-class problems with each other, [and] solving work as a group.

2) At the end of class I ask students to look over class notes, pick out the most important points or examples or definitions or procedures, and write them down again in a packet. That should be a neat summary of the important points from class each day.

These were coded as Collaborative/Cooperative Learning and Writing instructional strategies. These strategies were included in the most common instructional strategies given by instructors in the survey.

In Figure 6 are the responses given by Prof. Smith in the survey for SQ – 3, in which the instructional strategies were rated. In Figure 7 are the responses given by Prof. Smith in the survey for SQ – 4, describing her implementation of the given instructional strategies.
### Q3. Rate how important you feel the following teaching strategies are for use in a developmental mathematics classroom.

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Extremely Important</th>
<th>Very Important</th>
<th>Important</th>
<th>Not Very Important</th>
<th>Not Important at All</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provide pairs or small groups of students the opportunity to work together to explain a problem, interpret a graph, review another student's work, discuss the correct solution, or engage in a project.</td>
<td>☐ ☐ ☐ ☐ ☐ ☐</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assign Internet group projects (in or out of class) or technology activities.</td>
<td>☐ ☐ ☐ ☐ ☐ ☐</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ask students to work in pairs on a homework problem before class begins.</td>
<td>☐ ☐ ☐ ☐ ☐ ☐</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use student answers to guide classroom discussion.</td>
<td>☐ ☐ ☐ ☐ ☐ ☐</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Present examples that lead to patterns, which form the basis of mathematical rules.</td>
<td>☐ ☐ ☐ ☐ ☐ ☐</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respond to any answer given (right or wrong) and discuss the logical ramifications of trying to solve the problem using alternative methods.</td>
<td>☐ ☐ ☐ ☐ ☐ ☐</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ask questions to guide students to solutions of problems.</td>
<td>☐ ☐ ☐ ☐ ☐ ☐</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engage students in activities that lead them to develop conceptual understandings.</td>
<td>☐ ☐ ☐ ☐ ☐ ☐</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ask students to write questions that require explanations.</td>
<td>☐ ☐ ☐ ☐ ☐ ☐</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ask students at the beginning of class to write about what they learned from doing the homework.</td>
<td>☐ ☐ ☐ ☐ ☐ ☐</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Encourage students to take notes and/or keep track of important mathematics ideas and problem statements by writing a checklist on the board or disseminating a fact sheet.</td>
<td>☐ ☐ ☐ ☐ ☐ ☐</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Include a writing component in homework, student projects, investigation, and explorations of mathematical concepts.</td>
<td>☐ ☐ ☐ ☐ ☐ ☐</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Figure 6. Prof. Smith’s responses to SQ – 3.

Figure 6 indicates that Prof. Smith agrees that having groups of students work together, using student answers to guide discussions, engaging students in activities that lead them to conceptual understandings, and including a writing component as extremely important which matches with her initial description in SQ – 1. She also checked six more of the strategies as very important or important, and only one as not very important.
Q4. Describe your implementation of the following instructional strategies.

<table>
<thead>
<tr>
<th>Instructional Strategy</th>
<th>Have Implemented this Strategy</th>
<th>Have Not Implemented</th>
<th>Plan to Implement in the Future</th>
<th>Not Interested in Implementing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provide pairs or small groups of students the opportunity to work together to explain a problem, interpret a graph, review another student’s work, discuss the correct solution, or engage in a project.</td>
<td>☑</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Assign Internet group projects (in or out of class) or technology activities.</td>
<td>☑</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Ask students to work in pairs on a homework problem before class begins.</td>
<td>☑</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Use student answers to guide classroom discussion.</td>
<td>☑</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Present examples that lead to patterns, which form the basis of mathematical rules.</td>
<td>☑</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Respond to any answer given (right or wrong) and discuss the logical ramifications of trying to solve the problem using alternative methods.</td>
<td>☑</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Ask questions to guide students to solutions of problems.</td>
<td>☑</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Engage students in activities that lead them to develop conceptual understandings.</td>
<td>☑</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Ask students to write questions that require explanations.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☑</td>
</tr>
<tr>
<td>Ask students at the beginning of the class to write about what they learned from doing the homework.</td>
<td>☑</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Encourage students to take notes and/or keep track of important mathematics ideas and problem statements by writing a checklist on the board or disseminating a fact sheet.</td>
<td>☑</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Include a writing component in homework, student projects, investigation and explorations of mathematical concepts.</td>
<td>☑</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

**Figure 7.** Prof. Smith’s responses to SQ – 4.

In Figure 7, Prof. Smith indicated that she had attempted to implement all but one of the instructional strategies, which I previously presented in the survey results in SQ – 6 and SQ – 8 was not a popular strategy among instructors. Her answers in Figures 6 and 7 led me to want to investigate her instructional strategies further by observing her classroom practices.

**Instructional Strategies Observed.** The first time I observed Prof. Smith she had groups of three students come in and review with her over 10 minute increments. She previously had given them a set of homework problems to do for review and when they
came in for their 10 minute session, she had them take turns explaining to the group how they solved each problem. She asked the students leading questions to guide them to the solutions of the problems if any of the students had difficulty solving the problems. The following is an excerpt from one of the sessions:

**Problem #30 Write an equation for each line. Give the final answer in slope-intercept form if possible. Through (4, -3), m = 1**

Prof. Smith: Todd, can you tell me about #30 please?

Todd: They wanted us to write an equation for what they gave us so, I just plotted that point I think. I just plugged those into my equation, \( y = mx + b \), and I plugged in negative 3 for \( y \), 1 for \( m \), 4 for \( x \), and I just put the \( b \) there, then by doing that, I found out what \( b \) was, which was negative 7, so the equation would be \( y = 1x + (-7) \).

Prof. Smith: Okay, good. Can you move that around and put it in Standard form?

Todd: Standard form is…Ummm… I would just flip it around, wouldn’t I?

Prof. Smith: Yes, how do you do that?

Todd: I would subtract \( y \) and then once \( y \) was over there, I would subtract \( 1x + (-7) \) to both sides.

Prof Smith: So lets see you do that.

Todd: Neg. 1, then it would be 0 = 1x + (-7) – \( y \), then I would plus 7, which would be 7 = \( x \) – \( y \).

Prof. Smith: That’s good. That’s it. See you have \( x \) and \( y \) on one side and a number or constant on the other.

In this excerpt, Prof. Smith is allowing the student (Todd) to explain to the other two students involved in the review session, how he solved the problem step by step. The other students may have solved it this way, or not, but it is beneficial to the others to see how someone else solved the problem and hear him reason through the steps of the problem. This is an example of a Cooperative Learning instructional strategy that was
used throughout this lesson. When the students were unsure of how to solve one of the review problems, Prof. Smith asked them questions to help lead them to the solution, which is an example of a Question-Posing strategy.

In her post-observation interview, I asked Prof. Smith what her plans were for engaging the class that day and she described how the groups of three students would be explaining review problems from the textbook to each other. She explained the purpose as this:

I tell them it’s another way to be sure they’re ready for the test, because sometimes you think you know something, but you try to explain it to somebody and you find out that you don’t really know it really well. And another thing is they get to hear each other and they say, “Oh, I hadn’t thought of that.”

The second time I observed Prof. Smith she was teaching a lesson on Systems of Equations. She began the lesson with a traditional lecture, but incorporated a real-world business problem to explain how simple systems of equations work. As she set up the equations for this, she asked leading questions to have students help her. After setting up the equations, she talked to them about the different ways of solving a system of equations. They began solving them by graphing, followed by substitution. Within the lesson, Prof. Smith employed five different methods of instructional strategies for engaging students in the learning process: Use of Real-World problems, use of Textbook Problems, Collaborative/Cooperative Learning, Question-Posing, and Writing. In this next excerpt several of these instructional strategies are employed.

Prof. Smith: Okay, line up by your first name, A through Z. Move on down, move on down. We’ve got a knot in the middle here. Move on down. Come on don’t be afraid. Alright, be sure you know the name of the person on either side of you. A, B, C, D, E…Everybody ready?

Prof. Smith: Okay, Frank, who’s that? (David)
Prof. Smith: Okay, David, who’s that? (Prof. Smith continues on asking each student to name the one next to them to be sure they are in alphabetical order and they know each other’s names.)

Prof. Smith: Okay, remember how you work together? What do you do first? Talk to each other! Tell your partner what it is you’re doing so your partner can say, “wait a minute, let’s think this one through again” or “yeah, you’re doing it right.” Work Textbook Problems #10 and #12. Talk to your partner. Be sure you know your partner’s name.

(Students are working on the problems and talking together. Prof. Smith goes around to the different groups and checks on their progress.)

Prof. Smith: (Talking to a group of students) Now where are you going to start? You want to get either an x or a y by itself. Which do you want to do?

Female Student: Get the y by itself.

Prof. Smith: Alright, in that 2nd equation? So what do you have to do to get the y by itself?

Female Student: Get rid of it?

Prof. Smith: No, you want to keep the y, you want to get rid of anything attached to it…

Female Student: The x.

Prof. Smith: Okay, so what are you gonna do?

Female Student: The negative x?

Prof. Smith: That’s right, on both sides. Okay? (She writes the answers on the board for #10 and #12.) Did you get them (addressing the whole class)?

Male Student: I have no idea what I’m doing.

Prof. Smith: (Walking over to his group.) Really! Erica can’t help you?

Male Student: I’m just beating my head against the wall, until the math comes out.

Prof. Smith: (Laughs) Probably not the best plan. Okay, you’re good right (to Erica)? You’re helping him now. (Prof. Smith looks over Erica’s work to be sure that she is solving the problem correctly.)
Within this excerpt Collaborative/Cooperative Learning was employed, as well as use of Textbook Problems and Question-Posing. Finally at the end of the lesson, Prof. Smith had the students write in their “What I Learned” packet for the last five minutes of class.

In her post-observation interview, I asked Prof. Smith what her plans had been for engaging the class that day and she explained:

I’m looking for them to find a way to generalize it, so I’m looking for a way for them to recognize that it relates to something they’re familiar with, and I’m also looking for ways for them to share it with other people, because it helps them understand what they are doing. I always tell them, you know, nobody talks about a train leaving from here and a train leaving from there, or someone jumping off a cliff…Those are easy to visualize, that’s why they put them in the book, but we’ve got to be more relevant than mixing nuts and mixing acid. They’re always doing that in the books.

This explains the small business problem she used at the beginning of the class as an example for a system of equations, and why she had the students so involved in helping her derive the linear equations. She continued by saying:

We do lots of interactive group work. I have them explain to someone. I have them do a problem. I have them take notes. I try to present the information lots of ways. I always say it, and show it, and if I have an example, I’ll give the example. I have them write about how they’re doing in math. I always have that at the end of class. I’ll try to give them 2 or 3 minutes, and I’ll say now, go through your notes and write down again the most important things we did today. Summarize and keep that in your “What I Learned” packet.

From the second post-observation interview, I learned of her emphasis for employing Real-World problems, small group work, which is a Cooperative Learning strategy, and Writing.

On the third and final observation, Prof. Smith was teaching a lesson on the rules of exponents. She indicated to me prior to the lesson, that she had looked online but had not found any new ideas for teaching this concept, so she was going to use the textbook
examples. As she began the lesson on exponents she explained to the students that she did not want them to think of the rules of exponents as rules.

Prof. Smith: These are not really “rules”, these are just shortcuts, because if you work with exponents you’ll figure out that this is just the way they work. So instead of… For example, if I have $x^2$ times $x^3$, then that’s really how many $x$s? It’s $x$ times $x$ times $x$ times $x$ times $x$. So that’s how many $x$s?

Male Student: $x^5$

Prof. Smith: So, the rule says when you’re multiplying numbers with the same base you just add the exponents. Well that’s not the rule, that’s just saying, instead of writing all those $x$s out and counting them, that’s what’s going to happen. So, instead of trying to memorize the rules, if you just think about, you can take a smaller example and see what happens, that’s the same way.

Prof. Smith continued to explain the rest of the rules of exponents in the same manner. Once she had finished explaining the rules of exponents, the students spent the rest of the time working together on various exponent problems with the difficulty of the problems increasing throughout the lesson. The following excerpt highlights how Prof. Smith questions students as they work on problems together and how she encourages them to help each other and work together to solve the textbook problems.

**Problem #76**

\[(y^4)^5(y^3)^5\]

\[= (y^{20})(y^{15})\]

\[= y^{35}\]

Prof. Smith: (Walks around the room checking student answers. Most have answered correctly.) If we have 4 of these 5 times, how many do we really have?

Student: 20

Prof. Smith: If we have 3 of these 5 times, how many do we really have?

Student: 15

Prof. Smith: Okay so this is $y$ to the 20th and this is $y$ to the 15th. So now how many do we really have?
Student: 35

Prof. Smith: There you go. Good. Do you all agree? Did you all get \( y \) to the 35th? Okay! Help somebody with problem #78. This problem is using 2 or 3 of these rules all together. Help somebody. How do you help somebody? What do you do first?

Student: Talk.

Prof. Smith: Talk. Tell them what you’re doing.

At the beginning of the class, as she was going through the exponent rules with the students, she had the students comparing their processes and answering with a student nearby, which is an Interactive Lecturing instructional strategy for engaging students. In this excerpt a couple of students sitting next to each other were helping each other. However, 15 minutes later she had everyone get up and work with someone else in the class. And again, as there were 20 minutes of class remaining, she had the students line up by their birthdates. Those at the beginning and end of the line worked together for the remainder of class. Thus, Prof. Smith worked to have her students explain problems and discuss solutions together in a Cooperative Learning setting. Furthermore in the excerpt, Prof. Smith is using guiding questions to lead students to solutions of problems, which is a Question-Posing instructional strategy. Finally, during the last few minutes of class she had the students write in their “What I Learned” packets, which is a Writing strategy.

**Summary of Prof. Smith’s Instructional Strategies.** Within her lessons, Prof. Smith employed six different methods of instructional strategies for engaging students in the learning process: Use of Real-World problems, use of Textbook Problems, Collaborative/Cooperative Learning, Interactive Lecturing, Question-Posing, and Writing. These concur with the methods she reported in the survey, in both SQ – 2, and
SQ – 4. The use of Real-World problems and Textbook Problems were also included which were two of the new instructional strategy categories that were created from the survey.

**Professor Lily**

Prof. Lily was selected to participate in the case study, because like Prof. Smith she indicated a higher use of instructional strategies to promote active learning on the survey; taught a 1 hour 15 minute class on a day that I was also able to make the trip to visit Prof. Smith; taught an Intermediate Algebra course, which was different than Prof. Smith; and was within 2 hours of Columbia.

**Survey Response.** In the survey Prof. Lily described two instructional strategies for engaging students in the learning process in the following way:

I believe the first “strategy” for engaging students is to be engaged as an instructor. By that, I mean that instructors should exhibit enthusiasm and love of the subject matter. If the instructor is enthused and excited to learn, students see that it can be (dare I say) fun! Or, if not fun, it doesn’t have to be a monotonous, boring subject.

The second “strategy” I use is the use of terminology. I always use proper math terminology and I explain what each term means each time I use it in class. By connecting the terminology and going over definitions repeatedly, students start to become less intimidated by the use of such terms as “polynomial” and “distributive property.” They learn to speak the language of math instead of seeing “big math words.”

The first strategy was coded as Enthusiasm/Encouragement, which was included in the most common instructional strategies given by instructors in the survey. The second strategy was coded as Question-Posing, because in the classes I observed Prof. Lily engaged students in activities to lead them to understand math terminology or she asked them multiple questions to guide them to the correct mathematics terminology.
In Figure 8 are the responses given by Prof. Lily in the survey for SQ – 3, in which the instructional strategies were rated. In Figure 9 are the responses given by Prof. Lily in the survey for SQ – 4, describing her implementation of the given instructional strategies.

Q3. Rate how important you feel the following teaching strategies are for use in a developmental mathematics classroom.

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Extremely Important</th>
<th>Very Important</th>
<th>Important</th>
<th>Not Very Important</th>
<th>Not Important at All</th>
</tr>
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<tbody>
<tr>
<td>Provide pairs or small groups of students the opportunity to work together to explain a problem, interpret a graph, review another student's work, discuss the correct solution, or engage in a project.</td>
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<tr>
<td>Assign internet group projects (in or out of class) or technology activities.</td>
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<td>Ask students to work in pairs on a homework problem before class begins.</td>
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<tr>
<td>Use student answers to guide classroom discussion.</td>
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<tr>
<td>Present examples that lead to patterns, which form the basis of mathematical rules.</td>
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<tr>
<td>Respond to any answer given (right or wrong) and discuss the logical ramifications of trying to solve the problem using alternative methods.</td>
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<tr>
<td>Ask questions to guide students to solutions of problems.</td>
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<tr>
<td>Engage students in activities that lead them to develop conceptual understandings.</td>
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<tr>
<td>Ask students to write questions that require explanations.</td>
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<tr>
<td>Ask students at the beginning of class to write about what they learned from doing the homework.</td>
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<tr>
<td>Encourage students to take notes and/or keep track of important mathematics ideas and problem statements by writing a checklist on the board or disseminating a fact sheet.</td>
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<tr>
<td>Include a writing component in homework, student projects, investigation, and explorations of mathematical concepts.</td>
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Figure 8. Prof. Lily’s responses to SQ – 3.

In Figure 8 Prof. Lily indicates that using student answers to guide classroom discussion, presenting examples that lead to patterns, responding to any answer given, and asking questions to guide students to solutions of problems as extremely important.
From the observations I found these are exactly the types of instructional strategies she employs. She also checked it that it was important to engage students in activities that lead them to develop conceptual understandings, which matches with her description of strategy number two in SQ – 1. Prof. Lily only checked three strategies that were not very important or not important at all, which were similar to the majority of those who answered the survey.

**Q4. Describe your implementation of the following instructional strategies.**

<table>
<thead>
<tr>
<th>Provide pairs or small groups of students the opportunity to work together to explain a problem, interpret a graph, review another student's work, discuss the correct solution, or engage in a project.</th>
<th>Have Implemented</th>
<th>Have Not Implemented</th>
<th>Plan to Implement in the Future</th>
<th>Not Interested in Implementing</th>
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**Figure 9.** Prof. Lily’s responses to SQ – 4.

In Figure 9, Prof. Lily indicated that she had attempted to implement all but two of the instructional strategies, which I have previously shown in the survey results in SQ – 6 and SQ – 8 were not popular strategies among instructors. Her answers in Figures 8
and 9 led me to want to investigate her instructional strategies further by observing her classroom practices.

**Instructional Strategies Observed.** The first time I observed Prof. Lily she was working with her class on graphing linear equations. She began her classes by doing “basket problems,” which were homework problems that students struggled with and had put in the in-basket on the desk at the front of the room. She would go over these with the students for first 15 – 20 minutes of class. She then taught the lesson of the day. The following excerpt showcases how she integrated a Real-World problem to demonstrate the use of linear equations, focused on the proper use of math terminology, and asked questions to guide students to the solutions of problems. She also gave students a Note Packet for each section of the chapter.

**Problem:** In 1997, 36.4% of High School students smoked. In 2003, 21.9% of High School students smoked. Find the average rate of change in % per year.

Prof. Lily: That 4 work phrase tells you a lot. This is from the CDC. What is the average rate of change?

Student: The difference from one year to the next?

Prof. Lily: Yes, agreed. But there’s a mathematical word I’m looking for…

Student: Division?

Prof. Lily: Yes, but, it’s a difference.

Students: Is it the median? Mode?

Prof. Lily: Y’all are just throwing terms out. It has 5 letters. (She draws 5 spaces on the board for hangman.)

Students: SLOPE!

Prof. Lily: Slope. Average rate of change. It is the division between the differences. So, everybody was correct, but what I want you to do is
simplify it in your mind and then when you see average rate of change, just think “slope.” Okay, we don’t have a graph or visualizations, which means you have to have to points. Do you agree with that? Because we are going to have to use the formula. So I need you to tell me, if I can’t use rise over run and think graphically about this, what do I use?

Student: Is one (0, 36.4) and the other using 21.9?

Prof. Lily: Oh you could you use (0, 36.4) but for this problem they want you to keep the year. We’re not going to get into this too much, because we get in-depth in this in College Algebra, so I’m just going to touch on this real quickly. The x is always the independent variable. It’s the one that you get to choose. The y is the dependent variable and it depends on x. Why would the % of smokers depend on the year?

Student: Because it changes throughout the years.

Prof. Lily: Why?

Student: Because they told us that.

Prof. Lily: Think logically, mathematically…

Student: Because its not going to be the same every year.

Prof. Lily: Think about the 1960’s. Would you expect the % of people who smoked in the 1960’s to be higher or lower than 1997?

Student: Higher.

Prof. Lily: Why?

Students: Because (inaudible, several students talking at once.)

Prof. Lily: Ahhhhh, so with time comes knowledge. So, we would expect for these to be lower because when I went to college all of the chalkboards had rounded corners to set your cigarette on. They used to smoke in the classroom when they taught. Can you imagine that? Just think about when you’re doing the math of it, think of the impact of it in real life.

So, we need 2 points. \((x_1, y_1)\) and \((x_2, y_2)\). (1997, 36.4) and (2003, 21.9).

(6.4)/(2003-1997) which is % per year = \(-14.5/6 = -2.42\).

Ask a question about the numbers if yours aren’t matching up.
(Students are working individually to solve the problem.)

Student: You said that it’s okay if you have a negative rise and positive run?

Prof Lily: Sure is. (Chatter going on as students are solving the problem.)

Prof. Lily: Now, it’s not exact okay? So, we’re going to round it. Say we go to 2 decimal places. (Many students are beginning to get –2.42)

Prof. Lily: But, we’re not done. So, you get negative 2.42. Average rate of change is not completely slope right? It’s slope, but with labels. Okay, what did your top numbers represent?

Student: That was your %.

Prof. Lily: Percent per…and then what did you divide by?

Student: Year.

Prof. Lily: So why is it negative?

Student: Because smoking is going down.

Prof. Lily: You bet, about 2% less people are smoking each year. Now who else would care about this number of –2.42 besides the CDC, learning about the health of the population in the U.S? Who else would care about that number?

Students: Cigarette businesses?

Prof. Lily: You bet, if I’m a manufacturer I’m going to decrease my production a little bit. Maybe not quite that much just in case, but I want to make sure I’ve got product for my consumers if they need it. But, there’s a lot of people that care about average rate of change. This is just one example.

This Real-World problem demonstrates to the students how linear equations can be used to solve problems they can relate to, specifically those focusing on slope or rate of change. Throughout the problem Prof. Lily asks the students questions to guide them to the solution of the problem, which is a Question-Posing instructional strategy. This problem and the questions she asked the students also allowed them to develop a more
conceptual understanding of slope. In this excerpt she asked the students to explain “why” several times throughout the exchange, to encourage students to think at a deeper level when analyzing why the percent of smokers changed per year. Additionally, Prof. Lily was enthusiastic in her delivery of the material because she was always smiling at the students and encouraged them not to give up as they were solving this challenging problem.

The next excerpt is from the second observation in which Prof. Lily is teaching about functions. This excerpt shows how she uses little stories throughout her lessons to make them more interesting, as well as trying to find ways to help students understand and/or remember the math concepts they are learning.

Prof. Lily: Okay, So the last thing we did on Wednesday of last week, we talked about how to write the equation in function notation. So, just a reminder, remember Clark Kent. He’s casual, he’s just one of 26 letters of the alphabet, he’s a y right. You take the y put it in the front and whoosh, he comes out as f(x). He has a super power. So the y is common ordinary and f(x) has a super power. It is called a function and it will pass a vertical line test. This has special powers attached to it in math, that we can’t do with just “y”. So here is where we left off then. A linear function can be defined as f(x). It’s a function so it’s going to have a f(x). Now, what’s the equation of a line?

Student: \( y = mx + b \)

Prof. Lily: What did y do?

Student: It turned into \( f(x) \).

Prof. Lily: So guess what the last part of this is?

Student: \( mx + b \)

Prof. Lily: Do you see it’s the same thing as \( y = mx + b \)?

Student: Yes
Prof. Lily: It just turned the $y$ into a function, because lines are functions. Lines that have a slanty slope. Because we talked about the fact that vertical lines are not functions. So, here’s something they are going to ask you to do. They’re going to say…Graph $f(x) = \frac{1}{4} x - 2$

Student: You start at negative 2.

Prof. Lily: And this is the biggest hurdle to get over, right here. In your mind you’ve got to look at that and not be intimidated by the $f(x)$. This is the same thing as $y = \frac{1}{4} x - 2$. It’s very much a mental interpretation, the way you look at that. So yeah, we can start at – 2 on our y-axis and then what?

Student: Go up 1 over 4.

Prof. Lily: Rise 1, run 4.

The story she used in this excerpt, the use of Clark Kent changing into Superman, was Prof. Lily’s way of explaining how to rewrite the linear equation $y = mx + b$ into the function $f(x) = mx + b$. As the lesson continued she taught the students about functions and knowing when lines were functions or not. In the post-observation interview, Prof. Lily told me, “I try to put stories in, small little things to interject and add in there.” The stories are usually funny little ways to help the students remember math concepts. Additionally, this excerpt shows how she attempts to use questions throughout the lesson to lead them to conceptual understandings. Thus, again, as in the first observation, she is using the Question-Posing instructional strategy. Finally, at the beginning of this excerpt Prof. Lily mentioned the handout she would get for them. These are the note-packets that she creates for each section of each chapter for the students. They include the problems and pre-made graphs that they go over in class, which makes it much easier to take notes and create the graphs for the students. I considered this an Interactive Lecturing instructional strategy, because the students interact with the instructor using these notes throughout the lesson.
The next excerpt comes from my third observation of Prof. Lily. In this lesson Prof. Lily is teaching the students about exponents with radicals. They have learned about the rules of exponents in the course prior to this one, thus she begins with a little review of these rules.

**Let’s Play a game “Do You Agree?”**

Prof. Lily: The answer’s always yes, I’m not trying to confuse you, but you should answer the question yourself. If you don’t think, yes, then you should ask me a question. Do you agree, 2 to the 3rd power all raised to the 4th power is…

\[(2^3)^4 = 2^3 \cdot 2^3 \cdot 2^3 \cdot 2^3\]?

Students: Yes

Prof. Lily: Do you agree it’s also…

\[= (2 \cdot 2 \cdot 2) \cdot (2 \cdot 2 \cdot 2) \cdot (2 \cdot 2 \cdot 2) \cdot (2 \cdot 2 \cdot 2)?\]

Students: Yes

Prof. Lily: Do you agree it’s also equal to 2^{12}?

Students: Yes

Prof. Lily: So, you learned the rules of exponents back in the Fundamentals of Algebra. Do you remember the rules of exponents to avoid doing this long process?

Student: Yes, you multiply the powers.

Prof. Lily: A power to a power, you multiply it. You need to remember why it works as well, this is why I did this problem, not just that it does work. Now look at this guy…

**Problem:** \((3^{1/2})^2\)

So this is a power raised to a power, correct?

Students: (Inaudible.)
Prof. Lily: Okay, what’s ½ times 2?

Students: 1

Prof. Lily: 1, and 3 to the power of 1 is what?

Students: 3

Prof. Lily: 3, hmmm…isn’t that interesting?

Student: What’s the ½ power? Make it go away…

Prof. Lily: No. It’s only just begun. Okay square root of x is? Guess what a square root really is?

Student: ½?

Prof. Lily: It’s a fractional exponent. It is \(x^{\frac{1}{2}}\). So now we’re looking at what a square root means numerically in math besides just being a symbol, you’re taking \(x\) to the \(\frac{1}{2}\). What do you think a cube root is?

Student: \(x^{\frac{1}{3}}\)?

Prof. Lily: Yes! Guess what the 4th root of \(x\) is?

Student: \(x^{\frac{1}{4}}\).

Prof. Lily: Guess what the \(n\)th root of \(x\) is?

Students: \(x^{\frac{1}{n}}\)? No…

Prof. Lily: 1 over \(n\). It’s always 1 over your root when you have a radical like this. Okay, so do you remember how last time I told you that a square and square root undo each other? And I said just believe me, and you all just did?

Students: hmmm-hmmm

Prof. Lily: So look at this, the square root of 3 is actually 3 to the \(\frac{1}{2}\) power. If we go back and we square it, so go back and put parentheses around it and square it from the beginning, if we don’t cancel them right off the bat like we did last time, then you have 3 to the \(\frac{1}{2}\) power to the power of 2, and when you have a power to a power you multiply, correct, and that is just 3. This is the why a square and a square root cancel each other out. Mathematically here are the steps you are skipping to get there. It’s because it’s a fractional exponent.
Throughout this third lesson, Prof. Lily again used the Question-Posing instructional strategy. She was constantly asking questions to guide students to the solutions of problems and to help them develop conceptual understandings. Thus, in this excerpt, her intention was to lead students to a better understanding of the rules of exponents through the guiding questions she employed. For example in the problem \((2^{3})^{4}\), Prof. Lily asked the students about the multiple ways this problem can be represented and then ended the discussion by asking them what exponent rule could be used. In the post-observation interview she noted:

I tried to make it so that it was a building process, where the fraction exponent only had a numerator of 1, and then we moved to when the numerator was a different number other than 1, so we tried to build. Then I, on purpose, made them move back to the beginning of the material, because I didn’t want them to overcomplicate the problems. So, we did things in a certain order on purpose. One to build their knowledge, but another to challenge them, not to overthink the simple problems.

Thus, Prof. Lily is very deliberate in her use of examples to lead the students to a conceptual understanding of the material. Additionally, she was very enthusiastic about the mathematics, which draws the students into the lesson.

**Summary of Prof. Lily's Instructional Strategies.** Within her lessons, Prof. Lily employed four different methods of instructional strategies for engaging students in the learning process: Use of Real-World problems, Question-Posing, Interactive Lecturing (with the use of her note packets), and Enthusiasm. These concur with the methods she described she used in the survey, in both SQ – 2, and SQ – 4. The use of Real-World problems and Enthusiasm were also included which were two of the new instructional strategy categories that were created from the survey.
**Professor Buster**

Prof. Buster was selected to participate in the case study, because like Professors’ Smith and Lily, she indicated a higher use of instructional strategies to promote active learning on the survey; taught a 1 hour 20 min. class on a day that I was able to make the trip; taught an Elementary Algebra course, which was similar to Prof. Smith, but different than Prof. Lily’s; and was within 2 hours of Columbia.

**Survey Response.** In the survey Prof. Buster described two instructional strategies for engaging students in the learning process in the following way:

I involve students in a variety of activities, ranging from matching to ordering cards to creating and solving problems on individual dry erase boards to playing games, varying from individual to class to small group work. I also use music to stimulate memory and curiosity. Each class period involves at least one activity. Variety contributes to an active, engaged atmosphere.

Each student has his or her own folder, which serves as their communication center and organizer for the course. They see their attendance in the folder; they receive individualized feedback (in the form of post-it notes), they turn in their homework quizzes there; they receive graded materials, notes, and announcements there; they can see their grade so far, their attendance so far, how far into the course we are; what we’ll be studying next, etc. I decorate their folders with motivational quotes. My students can constantly monitor their progress and keep abreast of what is coming up by opening up their folders. Developmental students need to know that they are noticed and cared for.

The first strategy was coded as Collaborative/Cooperative Learning instructional strategies and the second strategy was coded as an Encouragement/Enthusiasm instructional strategy. Both of these strategies were included in the most common instructional strategies given by instructors in the survey.

In Figure 10 are the responses given by Prof. Buster in the survey for SQ – 3, in which the instructional strategies were rated. In Figure 11 are the responses given by Prof. Buster in the survey for SQ – 4, describing her implementation of the given
instructional strategies.

Figure 10 indicates that Prof. Buster agrees that having groups of students working together, using student answers to guide discussion, presenting examples that lead to patterns, responding to any answer given, asking questions to guide students to solutions of problems, and engaging students in activities that lead them to conceptual understandings as extremely important which matches with her initial description in SQ – 1. She also checked five more of the strategies as very important or important, and only one as not very important.

Table: Q3. Rate how important you feel the following teaching strategies are for use in a developmental mathematics classroom.

<table>
<thead>
<tr>
<th>Instruction</th>
<th>Extremely Important</th>
<th>Very Important</th>
<th>Important</th>
<th>Not Very Important</th>
<th>Not Important at All</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provide pairs or small groups of students the opportunity to work together to explain a problem, interpret a graph, review another student's work, discuss the correct solution, or engage in a project.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Assign Internet group projects (in or out of class) or technology activities.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Ask students to work in pairs on a homework problem before class begins.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Use student answers to guide classroom discussion.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Present examples that lead to patterns, which form the basis of mathematical rules.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Respond to any answer given (right or wrong) and discuss the logical ramifications of trying to solve the problem using alternative methods.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Ask questions to guide students to solutions of problems.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Engage students in activities that lead them to develop conceptual understandings.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Ask students to write questions that require explanations.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Ask students at the beginning of class to write about what they learned from doing the homework.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Encourage students to take notes and/or keep track of important mathematics ideas and problem statements by writing a checklist on the board or disseminating a fact sheet.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Include a writing component in homework, student projects, investigation, and explorations of mathematical concepts.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

Figure 10. Prof. Buster’s responses to SQ – 3.
In Figure 11, Prof. Buster indicated that she had attempted to implement all but one of the instructional strategies, which I previously showed in the survey results in SQ – 6 and SQ – 8 was not a popular strategy among instructors. Her answers in Figures 10 and 11 led me to want to investigate her instructional strategies further by observing her classroom practices.

Q4. Describe your implementation of the following instructional strategies.

<table>
<thead>
<tr>
<th>Instructional Strategies Observed.</th>
<th>Have Implemented this Strategy</th>
<th>Have Not Implemented</th>
<th>Plan to Implement in the Future</th>
<th>Not Interested in Implementing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provide pairs or small groups of students the opportunity to work together to explain a problem, interpret a graph, review another student's work, discuss the correct solution, or engage in a project.</td>
<td>✔️</td>
<td>❌</td>
<td>❌</td>
<td>❌</td>
</tr>
<tr>
<td>Assign Internet group projects (in or out of class) or technology activities.</td>
<td>❌</td>
<td>✔️</td>
<td>❌</td>
<td>❌</td>
</tr>
<tr>
<td>Ask students to work in pairs on a homework problem before class begins.</td>
<td>✔️</td>
<td>❌</td>
<td>❌</td>
<td>❌</td>
</tr>
<tr>
<td>Use student answers to guide classroom discussion.</td>
<td>✔️</td>
<td>❌</td>
<td>❌</td>
<td>❌</td>
</tr>
<tr>
<td>Present examples that lead to patterns, which form the basis of mathematical rules.</td>
<td>✔️</td>
<td>❌</td>
<td>❌</td>
<td>❌</td>
</tr>
<tr>
<td>Respond to any answer given (right or wrong) and discuss the logical ramifications of trying to solve the problem using alternative methods.</td>
<td>✔️</td>
<td>❌</td>
<td>❌</td>
<td>❌</td>
</tr>
<tr>
<td>Ask questions to guide students to solutions of problems.</td>
<td>✔️</td>
<td>❌</td>
<td>❌</td>
<td>❌</td>
</tr>
<tr>
<td>Engage students in activities that lead them to develop conceptual understandings.</td>
<td>✔️</td>
<td>❌</td>
<td>❌</td>
<td>❌</td>
</tr>
<tr>
<td>Ask students to write questions that require explanations.</td>
<td>✔️</td>
<td>❌</td>
<td>❌</td>
<td>❌</td>
</tr>
<tr>
<td>Ask students at the beginning of the class to write about what they learned from doing the homework.</td>
<td>✔️</td>
<td>❌</td>
<td>❌</td>
<td>❌</td>
</tr>
<tr>
<td>Encourage students to take notes and/or keep track of important mathematics ideas and problem statements by writing a checklist on the board or disseminating a fact sheet.</td>
<td>✔️</td>
<td>❌</td>
<td>❌</td>
<td>❌</td>
</tr>
<tr>
<td>Include a writing component in homework, student projects, investigation and explorations of mathematical concepts.</td>
<td>✔️</td>
<td>❌</td>
<td>❌</td>
<td>❌</td>
</tr>
</tbody>
</table>

Figure 11. Prof. Buster’s responses to SQ – 4.

Instructional Strategies Observed. The first time I observed Prof. Buster she was working with her class on graphing inequalities. In the following excerpt she is
engaging students in an activity that leads to a mathematical pattern, which aids in developing their conceptual understanding about inequalities.

Prof. Buster: Everybody has in their folder, a little green post-it note with a point on it. I’m going to divide up the chalkboard. On the right I’m going to put “Satisfies” this inequality \( y \geq 2x - 5 \) and on the left side I’m going to put up “Does not Satisfy” that inequality. I want you to figure out, “Does your point satisfy the inequality?” or “Does your point not satisfy the inequality?” And then I would like for you to walk up here and post your note under whichever side you think fits. How are you going to figure out whether your point satisfies the inequality?

Student: Plug in the point in the equation.

Prof. Buster: Plug in the \( x \), then plug in the \( y \) into the inequality and see if it’s true. If that comes out to be a true statement, you’re going to put your post-it note on this side (Satisfies). Your point is going to either satisfy the inequality or it’s not going to satisfy the inequality. Okay?

(Students are walking to the front. She guides those who are confused, to putting in the \( x \) and \( y \) for their point into the equation.)

Let’s check each of the points. (She substitutes each \( x \) and \( y \) into the equation and asks the class if it is a true statement. If the points are not placed in the correct spot, she asks the class if it works or doesn’t and then places it in the correct spot.)

Why on earth did we do all that? It looks like there are some points that satisfy the inequality and some points that don’t satisfy [it]. We’re going to make a picture and see what it’s telling us. Math is the study of patterns. Let’s see if we can catch a pattern from all of this. Let’s graph as if it was an equation, so instead of that greater than stuff, we are going to graph \( y = 2x - 5 \). Do you remember the quick way to graph a line? What form is this equation in?

Student: Point-slope form

Prof. Buster: It’s in point-slope form?

Student: It’s in the other one.

Prof. Buster: It’s in slope-intercept form. So, it should be giving us a slope and intercept just by looking at it. What’s the intercept? Where does it hit the \( y \)-axis?
Student: –5

Prof. Buster: See that –5. So, from the origin, 5 down. When we have a graph in slope-intercept form it’s very easy to graph. Now what’s the slope of this thing?

Student: 2 over 1

Prof. Buster: Right the rise is 2, the run is 1, over 1. So, up 2 over 1, there’s another point. (She makes several points and graphs her line.) This line is not an inequality, this line is an equation. We already graphed those types of lines a long time ago. But now we are going to put all these points on the graph. So point (1, -4) I’m going to graph it and make a sad face. It’s a bad point because we decided earlier it doesn’t satisfy the equation. (She plots the rest of the bad points with frowny faces.) That’s very interesting… (looking at where the bad points lie in the graph.)

Now let’s look at the good points. The points that satisfy the equation. (She plots those points with smiley faces.) Some are on the line, some are not. Anybody notice anything yet?

Students: (Inaudible)

Prof: Buster: Ah, are you starting to notice that this is a rather segregated group here? The smiles versus the frownies? What do you notice? Can somebody put that into words?

Students: They all look a mess. They are parallel. They are vertical. They are on the same side.

Prof. Buster: The same side! What do you mean? Do you notice there’s a good side to this line? And there’s a bad side to this line? All of our smiley faces on this side of the line, and all of our frowny, don’t satisfy faces are on this side. What about the points that are on the line itself? Do they satisfy?

Students: Yes

Prof. Buster: Well the line is where $y$ is exactly equal to $2x – 5$. We allowed that in our inequality. These smiley faces are where $y$ was greater than $2x – 5$. And we always shade the good side, the ones that work. Over on this side, none of these points satisfy. So when you graph an inequality it’s going to be all about making your line, that’s like a fence and then figuring out what’s the good side and what’s the bad side. And you’re always going to shade the good side. Is this making some sense to you?
In this excerpt, Prof. Buster uses several instructional strategies that promote active learning. First, she uses student answers to guide classroom discussion, presents examples that lead to patterns, and asks students to discover concepts or patterns, which is Discovery-Based Learning strategy. This can be seen in the post-it note activity, which Prof. Buster indicated in her post-observation interview that she does these types of activities where they have to categorize things on the board quite frequently. She said, “it’s important, because they all have to be involved, to walk up there and commit to putting it up there. Their name isn’t on it, so if it’s wrong, it’s not a big deal, we just move it to the right category.” Also, she had the students working together in pairs, which is a Cooperative Learning strategy. Throughout the lesson she asked questions to guide students to the solutions of problems, which is a Question-Posing strategy. Finally, she used note packets in her lesson like Prof. Lily did, which is an Interactive Lecture strategy.

The next excerpt is from the second lesson, in which I observed Prof. Buster teaching her students about the exponent rules. The way she taught the rules of exponents, she would have the students create the rules and then have them create an example of the rule.

Prof. Buster: So before we begin with exponents, somebody tell me what $x + x$ is?

Student: $2x$

Prof. Buster: Right, because you must have like terms to add or subtract. So, these are like terms... $x + x = 2x$. How about $x$ times $x$?

Student: $x^2$

Prof. Buster: Right, that’s what Archimedes invented. He wrote the $x$ once and put the squared on there. We call it squared or 2nd power, they mean the
same thing. Now we are going to start building on first rule. If I had $x^3$ times $x^5$, what does $x^3$ mean?

Student: $x$ times $x$ times $x$

Prof. Buster: You got it and $x^5$ means $x$ times $x$ times $x$ times $x$ times $x$. How many $x$’s do you see in your mind?

Student: 8

Prof. Buster: Do you see all 15 of them?

Student: No, 8.

Prof. Buster: Right so you have $x^8$. So invent a rule for me, if I have $x$ to a power, times $x$ to a power, what do I do with those powers?

Students: Add.

Prof. Buster: Add them together. So, now comes the first thing we are going to write on that handout. If we have $x^m \times x^n$, it’s going to give us $x$ to the what?

Student: $m + n$

Prof. Buster: Right you’re going to add those two powers. So that’s what you’re going to write. I started the rule for you on that page. You have to write $x^{m+n}$. Now what I’d like for you to do using the little white boards you have, I would like for you to make up an example of when you would use the rule $x^{m+n}$.

If you have a rule written and you are left-handed I’d like for you to put your white board up here on the ledge of the chalkboard.

Okay, so here’s our first one: $x^7 + x^4 = x^{11}$. Is this what we want?

Students: No.

Prof. Buster: So our new rule talks about multiplication. We should have a multiplication sign. Okay, the next example someone has up here is $x^4 \cdot x^7 = x^{11}$. So, is everybody okay with that rule and an example of how it works?

Prof. Buster continues teaching the rest of the exponent rules in a similar manner.

In the post-observation interview she indicated she was “just trying to get them involved
in creating the patterns they were seeing, the exponent rules, but also in creating examples.” Thus, like the previous lesson, she presented examples that led to patterns, that formed the basis of mathematical rules, and she used the students’ answers to guide the classroom discussion, all of which are Discovery-Based instructional strategies. In addition, she asked students questions to guide them to solutions of problems, as well as engaged them in activities that led them to conceptual understandings, which is a Question-Posing strategy. Finally, she used note packets in her lesson again, which is an Interactive Lecture strategy.

The final excerpt is from Prof. Buster’s third lesson focused on writing polynomials and factoring. She begins by having the students create and write an expression on their white boards that simplifies to an answer of $x^2$. Prof. Buster encourages them to use addition, subtraction, multiplication, division, any of their exponent rules they have learned. This exercise gets them warmed up for the next task she has them do.

Prof. Buster: Now I’d like for you to write me a $1^{st}$ degree binomial. (Looking at a student’s white board she asks the class about what the student has written.) $2x^7 + x^4$, what do you guys think? Is it a binomial?

Students: Hmmm…

Prof. Buster: It is binomial. It’s got 2 terms. How about it’s degree?

Student: 7th

Prof. Buster: Oh, we wanted a $1^{st}$ degree. (Looking at another student’s example.) $x + 2x$, the only problem with that is, is that they are like terms, so you could add them together and then it’s only a monomial. (Looking at another student’s example.) $2x + 4x$, again those are like terms, so when you put them together it’s just a monomial. (Looking at another student’s example.) $3x^1 + 1x^0$, beautiful, because that’s really $3x + 1$. 

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(More examples…) $x + 7, 5x + 3, 5x + 4$, beautiful. Those look good. How about this one, $3ab + 4cd$? What do you think? Binomial?

Students: Yes

Prof. Buster: There’s two terms. What’s it’s degree though?

Student: Two

Prof. Buster: Second degree. We want a 1st degree. Remember how we find the degree of a term?

Student: Add the…

Prof. Buster: Add all the exponents on all the variables. So if $b$ and $c$ are both variables, then that’s a 2nd degree in that term. Does that make sense to you? Alright, so once we have a binomial on there, that’s really truly a 1st degree binomial, I want you to put a little bitty 2, kind of up high on the right. I want you to square your binomial.

After talking about squaring the binomial, Prof. Buster has the students, write a conjugate for their binomial and multiply those two. They then talk about the difference of two squares. The conversation is a lot of fun, with all the different binomials the students have created. From this point, Prof. Buster turns to factoring and talks to the students about undoing multiplying the binomials. She began the class with Jeopardy music, so she related how the Jeopardy game gives you the answer first and you must come up with the question with factoring. The students were now going to work backwards with factoring in which they have the answer and must find the two binomials, or factors, that will give them that answer. In the post-observation interview Prof. Buster stated, “The whole idea behind Jeopardy is that same reversal. I wanted them to get, even if they didn’t learn how to factor today, I wanted them to have that reversal feeling, if nothing else came from today, I wanted them to know that multiplying and factoring are reverse operations.”
As before in her previous lessons, Prof. Buster used the students’ answers to guide the classroom discussion, which was a Discovery-Based instructional strategy. In addition, she asked students questions to guide them to solutions of problems, as well as engaged them in activities that led them to conceptual understandings, which was a Question-Posing strategy. She also had the students work together in pairs at times discussing their solutions, which was a Cooperative Learning instructional strategy. Finally, she was very enthusiastic and encouraging with her students.

**Summary of Prof. Buster’s Instructional Strategies.** Within her lessons, Prof. Buster employed five different methods of instructional strategies for engaging students in the learning process: Use of Discovery-Based Learning, Question-Posing, Interactive Lecturing (with the use of her note packets), Collaborative/Cooperative Learning, and Enthusiasm & Encouragement. These concur with the methods she described she used in the survey, in both SQ – 2, and SQ – 4. The use of Enthusiasm & Encouragement is included which was one of the new instructional strategy categories that was created from the survey. Additionally, it is important to note that Prof. Buster was the only instructor who used discovery-based learning in all of her observed lessons.

**Cognitive Complexity of the Tasks and Questions Employed**

In each of the observations for all three of the instructors I observed, I coded the cognitive complexity of the tasks and questions used throughout their lessons. I wanted to analyze the cognitive levels of the mathematics tasks and questions as developmental mathematics instructor were implementing their instructional strategies, because research indicates student learning is greatest in those classrooms where the tasks and discourse routinely engage students in higher-level thinking and reasoning (NCTM, 2014). Thus, it
was important to note whether the instructors’ use of active learning instructional strategies resulted in higher-levels of cognitive complexity of tasks and/or questions. This information aided in answering research question number three.

The Levels of Cognitive Demand for the Tasks were described and coding labels were given in Table 1. The Question Types were described and coding labels were given in Table 2. The frequency of the levels of cognitive demand for the tasks and the question types for Prof. Smith, Prof. Lily, and Prof. Buster, is given in Tables 19, 20, and 21 respectively.

**Table 19**

*Frequency of Cognitive Complexity of Tasks & Questions for Prof. Smith*

<table>
<thead>
<tr>
<th>Time</th>
<th>L1</th>
<th>L2</th>
<th>L3</th>
<th>L4</th>
<th>Q1.1</th>
<th>Q2.2</th>
<th>Q3.2</th>
<th>Q3.3</th>
<th>Q4.3</th>
<th>Q4.4</th>
<th>Q5.3</th>
<th>Q5.4</th>
<th>Q6.4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1(^{st}) Observation</td>
<td>15</td>
<td>20</td>
<td>34</td>
<td>59</td>
<td>14</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2(^{nd}) Observation</td>
<td>7</td>
<td>6</td>
<td>33</td>
<td>21</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>2</td>
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<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>3(^{rd}) Observation</td>
<td>2</td>
<td>10</td>
<td>10</td>
<td>5</td>
<td>32</td>
<td>2</td>
<td>1</td>
<td>12</td>
<td>5</td>
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<td>1</td>
<td>6</td>
<td>3</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

**Table 20**

*Frequency of Cognitive Complexity of Tasks & Questions for Prof. Lily*

<table>
<thead>
<tr>
<th>Time</th>
<th>L1</th>
<th>L2</th>
<th>L3</th>
<th>L4</th>
<th>Q1.1</th>
<th>Q2.2</th>
<th>Q3.2</th>
<th>Q3.3</th>
<th>Q4.3</th>
<th>Q4.4</th>
<th>Q5.3</th>
<th>Q5.4</th>
<th>Q6.4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1(^{st}) Observation</td>
<td>11</td>
<td>8</td>
<td>26</td>
<td>39</td>
<td>6</td>
<td>3</td>
<td>13</td>
<td>4</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2(^{nd}) Observation</td>
<td>11</td>
<td>6</td>
<td>11</td>
<td>61</td>
<td>18</td>
<td>16</td>
<td></td>
<td>3</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3(^{rd}) Observation</td>
<td>1</td>
<td>19</td>
<td>4</td>
<td>36</td>
<td>57</td>
<td>9</td>
<td>2</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1</td>
<td>41</td>
<td>18</td>
<td>73</td>
<td>157</td>
<td>33</td>
<td>5</td>
<td>35</td>
<td>4</td>
<td>7</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent</td>
<td>1</td>
<td>67</td>
<td>30</td>
<td>23</td>
<td>50</td>
<td>10</td>
<td>2</td>
<td>11</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
In Tables 19–21, one can see approximately 60% of the tasks used during the instructional strategies used to engage students in the learning process clustered around L2 – Procedures Without Connections and approximately 40% at L3 – Procedures with Connections. With respect to the cognitively complexity of the questions used during the instructional strategies to promote active learning, approximately 28% of the questions centered around Q1.1 – Gathering Information-Factual Knowledge/Remember; approximately 50% of the questions clustered around Q2.2 – Probing Thinking-Procedural Knowledge/Understand; and approximately 8% of the questions centered around Q3.2 – Probing Thinking-Procedural Knowledge/Apply. There were small percentages of higher-order questions also implemented, with a larger number, approximately 9% at Q4.3 – Making Mathematics Visible-Conceptual Knowledge/Analyze. Additionally, for all three participants, there was a small use of higher-level questions employed at Q5.3. Examples of coded tasks and questions are given in Table 22.
Table 22

*Examples of Coded Tasks and Questions*

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1</td>
<td>Memorization tasks.</td>
<td>What is x² times x³?</td>
</tr>
<tr>
<td>L2</td>
<td>Procedures without connections tasks.</td>
<td>Graph the line through the point (−3, 2) with a slope of −4/3. What is the equation of this line?</td>
</tr>
<tr>
<td>L3</td>
<td>Procedures with connections tasks.</td>
<td>If I have (xy)^m that equals x^m y^m. Everybody in the parentheses is being raised to that power. Make up an example of this rule. When could we use this rule? What would it look like?</td>
</tr>
<tr>
<td>L4</td>
<td>Doing mathematics tasks.</td>
<td>No examples.</td>
</tr>
<tr>
<td>Q1.1</td>
<td>Factual Knowledge/Remember</td>
<td>What’s the m stand for?</td>
</tr>
<tr>
<td>Q2.2</td>
<td>Procedural Knowledge/Understand</td>
<td>Is it factored the way I have it right now?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7(x + y) + z(x + y)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Remember, factored means it looks like an entire multiplication problem. Is this a multiplication problem?</td>
</tr>
<tr>
<td>Q3.2</td>
<td>Procedural Knowledge/Apply</td>
<td>How do we use 2 points in the point-slope form? (To write the equation of a line.)</td>
</tr>
<tr>
<td>Q3.3</td>
<td>Conceptual Knowledge/Apply</td>
<td>So invent a rule for me, if I have x to a power times x to a power, what do I do with those powers?</td>
</tr>
<tr>
<td>Q4.3</td>
<td>Conceptual Knowledge/Analyze</td>
<td>What is ½ of 2^100?</td>
</tr>
<tr>
<td>Q4.4</td>
<td>Meta-Cognitive Knowledge/Analyze</td>
<td>Would you expect the % of people who smoked in the 1960s to be higher or lower than in 1997? Why?</td>
</tr>
<tr>
<td>Q5.3</td>
<td>Conceptual Knowledge/Evaluate</td>
<td>( \frac{h^n}{h^n} = h^{n-n} ) (This is a student created example of the exponent rule for division.) This is very interesting! What do you think?</td>
</tr>
<tr>
<td>Q5.4</td>
<td>Meta-Cognitive Knowledge/Evaluate</td>
<td>Given the points (−3, −1), (0, 2), (2, 5), (5, 8) The problem is to decide if it is a function. (One of the students states it isn’t a function.) What? Why wouldn’t it be a function?</td>
</tr>
<tr>
<td>Q6.4</td>
<td>Meta-Cognitive Knowledge/Create</td>
<td>No examples.</td>
</tr>
</tbody>
</table>
Number of Tasks and Questions Observed During a Classroom Observation

The total number of tasks and questions observed over each 1 hour and 15 minute teaching session is represented in Figure 12. The number of tasks and questions may have varied for each instructor and between each instructor for several reasons: depending on the content that was being taught during that lesson, depending on where the students were in their understanding of the content (which was not being measured in this study), and depending on the type of instructional strategy the instructor was using for that lesson.

![Graph](image)

*Figure 12. Number of tasks and questions observed over a 1.25 hour teaching session.*

**Professor Smith.** In Prof. Smith’s three lessons, she first worked with groups of 3 students every 15 minutes reviewing for the upcoming test. With 32 tasks and 107 questions observed, there were approximately 3.3 questions asked per task. As explained earlier in the case study section of this paper, Prof. Smith employed the Cooperative
Learning instructional strategy throughout the lesson by having the students explain the review problems to each other. Prof. Smith also used the Question-Posing strategy by using guiding questions to lead them to the solution when the students were unsure of how to solve one of the review problems.

In the second lesson I observed, Prof. Smith taught about systems of equations and graphing lines. With 13 tasks and 62 questions observed, there were approximately 4.8 questions asked per task. She began the lesson with a traditional lecture, but incorporated a real-world business problem to explain how simple systems of equations work. As she set up the equations for this, she asked leading questions to have students help her. After setting up the equations, she talked to them about the different ways of solving a system of equations. They began solving them by graphing, followed by substitution. Within the lesson, Prof. Smith employed five different methods of instructional strategies for engaging students in the learning process: Use of Real-World problems, use of Textbook Problems, Collaborative/Cooperative Learning, Question-Posing, and Writing. When teaching about systems of equations, Prof. Smith asked more guiding questions to help them solve the task, thus explaining the higher number of questions used.

In the third and final lesson that I observed, Prof. Smith covered the rules of exponents. With 21 tasks and 57 questions observed, there were approximately 2.7 questions asked per task. At the beginning of the class, as she was going through the exponent rules with the students, she had the students comparing their processes and answering with a student nearby, which was an Interactive Lecturing instructional strategy. Next, she had the students work together in small groups for the remainder of
class in a Cooperative Learning setting. Furthermore, Prof. Smith used guiding questions while they were working together to lead students to solutions of problems, which was a Question-Posing instructional strategy. Finally, during the last few minutes of class she had the students write in their “What I Learned” packets, which was a Writing strategy. When teaching about rules of exponents, the problems or tasks for the content may have been quicker for them to solve, and the students were working together and helping each other, thus Prof. Smith did not have to ask as many questions per task.

**Professor Lily.** In Prof. Lily’s three lessons, she first taught about equations of lines. With 19 tasks and 95 questions observed, there were approximately 5.0 questions asked per task. Prof. Lily integrated a Real-World problem to demonstrate the use of linear equations, asked questions to guide students to the solutions of problems (Question-Posing strategy), and gave students a Note Packet for each section of the chapter (Interactive Lecturing strategy). Additionally, Prof. Lily was enthusiastic and encouraging in her delivery of the material.

In the second lesson I observed, Prof. Lily taught about linear equations and functions. With 16 tasks and 111 questions observed, there were approximately 6.9 questions asked per task. Like in the first observation, she used the Question-Posing instructional strategy by asking guiding questions to lead students to the solutions of problems and she gave her students the note packets to use, which was an Interactive Lecturing strategy. When teaching about linear equations and functions, the content was more challenging than the previous lesson. Thus, the tasks may have more difficult to solve than the first lesson I observed, resulting in Prof. Lily asking more guiding questions to solve the tasks.
In the final observation, Prof. Lily finished a section on radical functions and started a new section on the rules of exponents. With 25 tasks and 111 questions observed, there were approximately 4.4 questions asked per task. Throughout this third lesson, she again used the Question-Posing instructional strategy. As previously explained in the case study section of this paper, Prof. Lily was constantly asking questions to guide students to the solutions of problems and to help them develop conceptual understandings. She also used the Enthusiasm/Encouragement strategy. Like Prof. Smith, Prof. Lily asked fewer questions per task when teaching her students about the rules of exponents, but she also taught about radical functions, so one must take that into account. It would be best to break down the questions per task per content during her 1.25-hour of teaching if we were to compare across the instructors.

**Professor Buster.** Lastly, in Prof. Buster’s three lessons, she first taught about graphing inequalities. With 6 tasks and 71 questions observed, there were approximately 11.8 questions asked per task. She used student answers to guide classroom discussion, presented examples that led to patterns, and asked students to discover concepts or patterns, which were Discovery-Based Learning strategies. This was described the post-it note activity in the case study section of this paper. Prof. Buster also had the students working together in pairs, which was a Cooperative Learning strategy; she asked questions to guide students to the solutions of problems, which was a Question-Posing strategy; and she used note packets in her lesson, which was an Interactive Lecture strategy. Prof. Buster asked the most questions per task.

In the second lesson I observed, Prof. Buster taught about the rules of exponents. With 7 tasks and 105 questions observed, there were approximately 15.0 questions asked
per task. Again in this lesson, she presented examples that led to patterns, that formed the basis of mathematical rules, and she used the students’ answers to guide the classroom discussion, all of which were Discovery-Based instructional strategies. In addition, she asked students questions to guide them to solutions of problems (Question-Posing strategy) and used note packets in her lesson (Interactive Lecturing strategy). Although Prof. Buster taught about the rules of exponents, which the other 2 instructors also taught, the number of questions per task was much higher than the other 2 instructors.

In the last lesson I observed Prof. Buster covered polynomials and factoring. With 15 tasks and 97 questions observed, there were approximately 6.5 questions asked per task. As before in her previous lessons, she used the students’ answers to guide the classroom discussion, which was a Discovery-Based instructional strategy. In addition, she asked students questions to guide them to solutions of problems, as well as engaged them in activities that led them to conceptual understandings, which was a Question-Posing strategy. She also had the students work together in pairs at times discussing their solutions, which was a Cooperative Learning instructional strategy. In all three of her lessons, she was enthusiastic and encouraging with her students. In this lesson, Prof. Buster asked the fewest questions per tasks as compared to the first two lessons I observed. She still asked more questions per tasks than Prof. Smith and Prof. Lily. She used the same instructional strategies as before, but the content was different. An analysis of the relationship between the complexity of the tasks and the number of questions and the cognitive complexity of the questions may be performed in the future.
Support Needed for Developmental Mathematics Instructors

The final purpose of this study was to investigate whether instructors felt they needed professional development to aid in the implementation of instructional strategies to engage students in the learning process. It was important to inquire if instructors felt the need to participate in professional development, since few of the instructors teaching developmental education courses may have been specifically trained to teach developmental students. In fact in the post-observation interviews of Professors Smith, Lily, and Buster, I asked each of them what kind of training they had received for teaching developmental mathematics.

Prof. Smith and Prof. Buster both stated they had gone to mentoring workshops and conferences, and received some professional development from those. Prof. Buster stated that she has presented some of her own ideas for teaching developmental mathematics at MEGSL and MOMATYC conferences. Additionally Prof. Smith informed me that she “did a really interesting NSF Grant with Truman State where they studied math anxiety and how that relates to student success.” Prof. Lily stated that her training was, “baptism by fire.” She has since learned to teach developmental mathematics the most through her of years of experience in teaching these courses. When she first started teaching developmental mathematics courses, she was baffled with the numbers of students who got through the K–12 system who were unable to add and subtract integers. Her response was, “I had to switch my way of thinking from ‘why do you not know this’ to ‘how can I make you understand this and retain it in a meaningful way’?”. Each of the participants agreed that they had learned the most in how to teach developmental mathematics through their experiences in teaching these courses.
After each observation, I asked Professors Smith, Lily, and Buster what types of instructional support they felt would have been helpful for them in designing or using instructional strategies to engage students in the learning process in that day’s topic. Several themes stood out in their conversations: the need to enhance their curriculum; time to get together to discuss mathematics; and participating in professional development. Each participant recognized the need for these, but struggled with how to get them enacted at her institution.

Need to Enhance the Curriculum

With respect to curriculum, the participants all used Pearson textbooks for their developmental mathematics courses. Both Professors Smith and Lily used the textbook, *Beginning and Intermediate Algebra, 5th Ed.*, written by Lial, Hornsby, and McGinnis, and published by Pearson in 2011. Prof. Buster used the textbook, *Prealgebra and Introductory Algebra, 4th Ed.*, written by Elayn Martin-Gay, and published by Pearson in 2014. Both of these textbooks include *MyMathLab*, which is an interactive online math homework, quiz, and test addition to the Pearson textbook.

Professors Smith and Lily give most of the credit to the book for the development of their lessons. Prof. Smith indicated that she,

explains things the way the book does, and I’ll explain to [the students], there may be other ways to do this, but in case you want to look again or look at the book for help, we want to always be doing it the same way.

Prof. Lily stated that the Pearson book has a site online where you can look at helpful tips that teachers from schools all over the nation have added. Despite this, all three participants felt the need to supplement the textbook with other materials.
After being asked what support she could have used to plan that day’s lesson on teaching the rules of exponents, Prof. Smith told me she needed some “sample lessons.”

She explains,

I was reading last week about cognitively demanding tasks and how they’re hard to come up with day after day. It would be really good to have lots of examples out there…because that’s especially, with something like the exponent rules, it’s like, it’s just a bunch of rules. They don’t understand them. They don’t remember them. They don’t keep them straight. Where, if we could find ways for them do discover that, “hey, this is just the way they work” that might work better.

Prof. Smith was referring to the Wilhelm (2014) article on *Mathematics Teachers’ Enactment of Cognitively Demanding Tasks: Investigating Links to Teachers’ Knowledge and Conceptions*. The author of this article studied how middle school mathematics teachers’ knowledge affected their enactment of cognitively demanding tasks.

Finally, each of the participants spoke of searching for lessons on the Internet to give them new ways to teach the material. Professors Lily and Buster both mentioned the *Teachers Pay Teachers* website as a good resource. Prof. Lily also stated she goes to *YouTube* to find out if there are better ways to teach a subject she is working on. Thus, these instructors are constantly searching for new, different, or better teaching materials and ways of reaching their students in their developmental mathematics courses.

**Time to Get Together to Discuss Mathematics**

All three participants talked about how they got together with the mathematics faculty at their institutions for meetings once or twice a semester. They all mentioned that there is usually too much that has to be discussed with respect to other things at these meetings besides their teaching, there’s not enough meetings, and there is not enough time in the meetings to discuss with each other how they teach different concepts. These meetings are primarily for full-time faculty also.
Prof. Buster was planning on setting up a Teaching Squares program at her institution. She explained it in the following way:

It’s groups of four teachers who go and observe each other’s classes. They then get together afterward and it’s not supposed to be to evaluate the other teacher at all. It’s supposed to be purely supportive and talking about what you saw and getting ideas for yourself and become a better teacher through that discussion. I’m thinking that observing is so important, so I’m trying to get those teachers together right now and trying to get some funding for it. That’s a lot of time for our adjuncts to commit to and it’s really not fair to be asking them to do that, so I want to get some funding.

Thus, Prof. Buster’s idea was to get instructors together to see what others are doing in their classrooms, talk about how those teaching methods work for them, and think about how they might incorporate some new ideas in their classrooms.

**Participating in Professional Development**

When listening to the participants I heard two main issues that hampered those from participating in professional development. First, both Prof. Smith and Prof. Buster indicated that they were the ones providing the professional development at the conferences they were attending statewide. Thus, attendance at a national conference might be a good suggestion for these participants to learn new instructional strategies. Funding would be required in order for them to do this.

The second issue is getting adjuncts to attend professional development (PD). Time and funding are the biggest factors influencing whether adjuncts are able to attend these meetings. According to Prof. Lily, “PD is always, a good idea, but it’s a barrier.” At her institution, there are multiple sites, approximately 60 miles apart, with adjunct instructors teaching at multiple sites. The adjunct may not live close to the site that you hold the PD at, so they hold multiple PD sessions to reach all the adjunct instructors and they still have low attendance. Moreover, because these instructors teach at multiple sites,
they have little time to attend PD. Prof. Buster stated that at her institution, “there’s not pay for them to do PD and [they] have wonderful adjuncts and they are brilliant, but it’s not really fair to ask them to [attend PD without pay].” Like Prof. Lily, she also stated it is hard to find a time to set up PD that worked for all of the adjunct instructors.

In summary, the three participants that were involved in the case studies did indicate they needed some support to do their jobs better. They all spoke of finding more curriculum and instructional strategies for reaching their students in their developmental mathematics courses; they want to find more time to be able to get together to discuss how they teach and see how others teach their developmental mathematics courses; and they want to be able to fund and schedule more time for professional developmental for both full-time and part-time instructors.
CHAPTER 5: DISCUSSION, SUMMARY, AND RECOMMENDATIONS

This study sought to identify the instructional strategies used by developmental mathematics instructors in Missouri’s public 2-year colleges to engage students in the learning process, determine the cognitive complexity of the instructional strategies, and find out the support needed by these instructors to engage their students in the learning process. This study was informed by the research-based framework of instructional strategies to promote active learning (AMATYC, 2006) listed in Table 1. Moreover, this study was based on the conceptual framework of The Task Analysis Guide created by Smith and Stein (1998, p. 348) to determine the cognitive complexity of the tasks employed during the instructional strategies. Finally, this study utilized the revised version of Blooms’ Taxonomy by Anderson and Krathwohl (2001) synthesized with the framework for the types of questions used in mathematics teaching as recommended by NCTM (2014) to determine the cognitive complexity of the questions utilized during the instructional strategies.

In this chapter, I summarize the dissertation research, discuss the major findings, and offer implications. More specifically, this chapter is divided into six sections: (1) Summary of the Study and the Findings, (2) Discussion of the Findings, (3) Implications of the Study, (4) Limitations of the Study, (5) Recommendations for Future Research, and (6) Final Thoughts.

Summary of the Study and the Findings

The Missouri Department of Higher Education (MDHE) is working towards the goal of having 60% of the residents attain some type of postsecondary diploma, which will require improvements in postsecondary education, specifically developmental
education (Radford et al., 2012). The recommendation from a report commissioned by the MDHE was to create and implement programs and/or policies that would improve the way developmental education is taught. As a result, Missouri House Bill 1042 was signed into law to ensure that institutions were implementing researched-based practices to increase student retention and educational completion in credit-bearing coursework (MDHE, 2013).

The Missouri Coordinating Board for Higher Education created their own Principles of Best Practices in Remedial Education (MDHE, 2013), which included exploring alternate delivery methods to provide instruction for developmental students. As previously mentioned, one such alternate instructional method recommended by Boylan (2002) for successful developmental education was the use of active learning techniques or the use of instructional strategies to engage students in the learning process. Active learning techniques should be implemented, because what we do know is that the traditional, lecture format type of instruction, involving passive learning that is typically provided to developmental mathematics students, did not work for them in their previous schooling, and is still not well suited to their needs (Boylan, 2002; Cox, 2009; Grubb et al., 1999; Perin, 2013).

Purpose of the Study

The purpose of this study was to investigate and characterize the instructional strategies used by developmental mathematics instructors in Missouri’s public 2-year colleges to engage students in the learning process, determine the cognitive complexity of the instructional strategies, and find out the support needed by these instructors to engage
their students in the learning process. This study addressed the following research questions:

1. How do Missouri community college developmental mathematics instructors describe the instructional strategies they use to promote active learning?
2. What instructional strategies used to promote active learning, as recommended by AMATYC, do developmental mathematics instructors rate as important and indicate they employ in their classrooms?
3. What is the cognitive complexity of the mathematical tasks and questions employed by the instructors during the instructional strategies?
4. What types of professional development do Missouri community college developmental mathematics instructors indicate is needed in order to successfully implement instructional strategies to promote active learning in their instruction?

Methodology

For this study I chose to use a sequential mixed method strategy (Creswell, 2009). A survey was used to obtain the quantitative and initial qualitative data, so that I could hear numerous teachers’ voices in their descriptions of the instructional strategies they use to engage students in the learning process. The initial participants for this study were the developmental mathematics instructors from all 13 of Missouri’s 2-year public community colleges (CCs). Quantitative analysis was completed on the demographic data, as well as the rating and implementation of the recommended AMATYC instructional strategies using the Qualtrics survey tool. Qualitative analysis was completed on the instructor descriptions of strategies for engaging students in the learning process later.
Next, three participants were chosen from the survey for case study analysis in which three observations, three post-observation interviews, and the handouts instructors gave to students during observations, were used to obtain more extensive qualitative data. Of the 31 respondents who consented to classroom observations, three participants were chosen for the case studies based on the following criteria:

1. participants who indicated a higher use of instructional strategies to promote active learning in how they described and rated the instructional strategies they used to promote active learning,

2. instructors who taught for approximately the same amount of time in their classes,

3. instructors who taught various developmental mathematics courses,

4. the time of day and week that they taught, and

5. the proximity of the community college to Columbia, MO.

Once all of the qualitative data was collected, each of the observations and interviews were transcribed and coded. For analysis I relied on the AMATYC (2006) framework of instructional strategies to promote active learning (Table 1), to identify the initial primary and secondary codes. Additional instructional strategy codes did emerge as a result of the data analysis, which was explained in Chapter 3.

The cognitive complexity of the instructional tasks and questions posed during the observations were also coded. For this analysis I relied on the *The Task Analysis Guide* created by Smith and Stein (1998, p. 348) and the taxonomy I created in Table 3, the *Framework for Determining the Cognitive Level of the Types of Questions Used in Mathematics Teaching*. As previously stated, I created this taxonomy by merging the Framework for the Types of Questions used in Mathematics Teaching as recommended
by NCTM (2014), with the cognitive dimension of the revised version of Blooms’ Taxonomy by Anderson and Krathwohl (2001).

Results of the Study

The results of the study were reported in five sections of Chapter 4: (1) Initiation of the Active Learning Survey, (2) Case Studies, (3) Active Learning Instructional Strategies Implemented by the Instructors, (4) Cognitive Complexity of the Tasks and Questions Employed, and (5) Support Needed for Developmental Mathematics Instructors. There was a suitable response rate for the survey, for of the 494 instructors contacted 185 started the survey with 146 participants actually completing the entire survey, resulting in a 30% response rate of total completion. The timeliness of the study, I believe aided in the response rate.

The demographic questions began with the instructors’ work status, and it is interesting to note that of the developmental mathematics instructors that responded, 58% were PT or adjuncts while the other 42% were FT. Approximately half the instructors indicated they had taught at the high school level, 41% had taught at the middle school/junior high level, and approximately one-third had taught at the four-year college or four-year university level.

With respect to their educational background, approximately 35% of the instructors indicated they had bachelors’ degrees in mathematics, 35% in mathematics education, and 15% in education in some other non-math education-related field. Likewise, approximately 30% of the participants indicated they had masters’ degrees in mathematics, 20% in mathematics education, and 20% in education in some other non-math education-related field. Thus, nearly half of the instructors had some pedagogical
training in their bachelors’ and masters’ programs. A cross-tabulation of the degrees completed by Missouri developmental mathematics instructors compared to their work status indicate that more PT than FT instructors earned bachelors and masters degrees in mathematics education or in education in some other non-math education-related field. The information given indicated a high level of training with respect to pedagogy and mathematics of the developmental mathematics instructors in Missouri who were either FT or PT.

The final demographic question in the survey asked the instructors which professional societies they were currently members of. The instructors are members of many professional societies with the main ones being NCTM, MCTM, AMATYC, MOMATYC, AMS, MAA, and MCCA. Twice as many FT instructors belonged to NCTM as PT instructors. However, almost 3 times as many PT instructors belonged to MCTM as FT instructors. That is where the comparison ends. The majority of the memberships to the remaining professional societies are by FT instructors.

From the survey I was able to learn how developmental instructors describe the methods they use to engage students in the learning process. They described their methods comparably to those instructional strategies that were recommended by AMATYC (2006) to promote active learning in Table 1, while also including some other strategies. The instructional strategies included (from highest to lowest frequency):

- Collaborative/Cooperative Learning (providing pairs or small groups of students the opportunity to solve textbook problems, explain the problem, and/or discuss the solution) (Frequency of 60),
- Use of Textbook Problems (Frequency of 59),
• Enthusiasm/Encouragement (Frequency of 32),
• Computer-Assisted Technology (Frequency of 30),
• Question-Posing (using guiding questions to lead students to the solutions of problems, engaging students in activities to develop conceptual understanding) (Frequency of 26),
• Working One-on-One with Students (Frequency of 25),
• Use of Real-World Problems (Frequency of 21),
• Interactive Lecturing (using note packets during the lecture, having students comparing processes, and solving the problem using alternative methods) (Frequency of 19), and
• Incorporating Writing (taking notes during class and writing about homework) (Frequency of 11).

Examples of descriptions of these instructional strategies were given in Table 11.

When instructors were asked to rate the importance of given instructional strategies from AMATYC (2006) the top 5 of the 12 choices that rated from “Extremely Important” (rated as 1) to “Very Important” (rated as 2) from highest to lowest were:

• Question-Posing (use of guiding questions to lead students to the solutions of problems) (Mean of 1.46),
• Discovery-Based Learning (present examples that lead to patterns) (Mean of 1.55),
• Interactive Lecturing (respond to any answer given, right or wrong, and discuss the implications of solving the problem using alternative methods) (Mean of 1.70),
• Question-Posing (engaging students in activities to develop conceptual understanding) (Mean of 1.85), and
• Discovery-Based Learning (using student answers to guide discussion) (Mean of 1.93).

The next two strategies were rated as “Very Important” (rated as 2) to “Important” (rated as 3):

• Writing (encouraging students to take notes and/or keeping track of important mathematics ideas and problem statements) (Mean of 2.27) and,
• Collaborative/Cooperative Learning (providing pairs or small groups of students the opportunity to solve textbook problems, explain the problem, and/or discuss the solution) (Mean of 2.36).

When asked whether or not the instructors had implemented the suggested instructional strategies, instructors chose the same seven as those for which they indicated they had already implemented that strategy.

Examples of reasons why instructors implemented the AMATYC (2006) strategies include:

• Having students work together in pairs or small groups gives them the chance to explain to others how they solved problems,
• Using students’ answers for guiding the class discussion is helpful for evaluating students’ understanding and then using their answers to give additional examples that can lead to better understanding for the students, and
• When asking questions to guide students to solutions it is important that students learn to question what they are doing and why.
The two instructional strategies that were rated the lowest between “Important” (rated as 3) and “Not Very Important” (rated as 4), as well as those strategies that instructors were “Not Interested in Implementing” (rated as 5) were:

- Writing (asking students at the beginning of class to write about what they learned from doing the homework) (Mean of 3.60) and

- Collaborative/Cooperative Learning (assigning Internet group projects) (Mean of 3.61).

An example of why an instructor chose not to implement the previous writing strategy was that instructors indicated that students in developmental mathematics often did not understand what they had learned from their homework. One instructor stated it was more important for her to link the homework to the content she was teaching in class so students would see the value in what they learned rather than have the students write about what they learned. For the reasoning of why instructors would choose not to implement the strategy of assigning an Internet group projects, not having reliable Internet access at home is a deterrent and trying to coordinate the schedules of non-traditional students who have jobs and family outside of class for group work was also a deterrent.

From the survey, three instructors were selected who had indicated a high usage of instructional strategies that promote active learning, in order to observe what instructional strategies were actually being used in the classroom. Prof. Smith employed six different methods of instructional strategies for engaging students in the learning process: Use of Real-World problems, use of Textbook Problems, Collaborative/Cooperative Learning, Interactive Lecturing, Question-Posing, and
Writing. These concur with the methods she reported in the survey. Within her lessons, Prof. Lily employed four different methods of instructional strategies for engaging students in the learning process: Use of Real-World problems, Question-Posing, Interactive Lecturing (with the use of her note packets), and Enthusiasm. Likewise, these concur with the methods she described she used in the survey. Finally, within her lessons, Prof. Buster employed five different methods of instructional strategies for engaging students in the learning process: Use of Discovery-Based Learning, Question-Posing, Interactive Lecturing (with the use of her note packets), Collaborative/Cooperative Learning, and Enthusiasm & Encouragement. Like the other two participants, the instructional strategies she implemented concurred with the methods she described she used in the survey.

Next, I determined the cognitive complexity of the tasks and questions employed by the instructors during the instructional strategies to promote active learning. I found approximately 60% of the tasks were clustered around level L2 – Procedures Without Connections and approximately 40% were at level L3 – Procedures with Connections, with no tasks at level L4 – Doing Mathematics. Additionally, with respect to the cognitively complexity of the questions used during the instructional strategies to promote active learning, approximately 28% of the questions centered around Gathering Information-Factual Knowledge/Remember, 50% of the questions focused on Probing Thinking-Procedural Knowledge/Understand, and approximately 8% of the questions centered around Q3.2 – Probing Thinking-Procedural Knowledge/Apply. There were small percentages of higher-order questions also implemented, with a larger number, approximately 9% at Making Mathematics Visible-Conceptual Knowledge/Analyze.
Furthermore, for all three participants, there was a small use of higher-level questions employed at Making Mathematics Visible-Conceptual Knowledge/Evaluate. There were little (1%) to no questions employed by instructors Encouraging Reflection & Justification-Meta-Cognitive Knowledge.

The number of tasks and questions was also tabulated for each of the three observations of the three case study participants. The results were shown in Figure 12. I found with Prof. Smith that she asked 3.3 questions per task in the first lesson I observed, 4.8 questions per task in the second lesson, and 2.7 questions per task in the third lesson. With Prof. Lily I found that she asked 5.0 questions per task in the first lesson I observed, 6.9 questions per task in the second lesson, and 4.4 questions per task in the third lesson. Last with Prof. Buster, I found that she asked 11.8 questions per task in the first lesson I observed, 15.0 in the second lesson, and 6.5 questions per task in the third lesson. The number of tasks and questions per observation varied for each instructor, as well as between each instructor.

After observing the instructors, I conducted post-interviews in which I asked each of them whether they felt they needed professional development to aid in the implementation of instructional strategies to engage students in the learning process. All three case studies indicated they needed some support to do their jobs better. They all spoke of (1) finding additional curriculum and instructional strategies to better support and explain the content to their students in their developmental mathematics courses; (2) wanting to work with other developmental mathematics instructors to discuss their teaching strategies and to possibly observe others’ teaching; and (3) wanting to procure
funding and schedule more time for professional developmental for both full-time and part-time instructors.

Discussion of the Findings

In this section the findings will be discussed in relation to answering the research questions and what connections there are from the literature to them. Four topics are included in this Discussion of Findings: (1) Instructors’ Description of Strategies Used to Promote Active Learning, (2) Instructional Strategies Rated as Important and Those Initially Described, (3) Instructional Strategies Observed and the Cognitive Complexity Involved, and (4) Support Needed to Implement Instructional Strategies.

Instructors’ Description of Strategies Used to Promote Active Learning

When asked at the beginning of the survey how instructors would describe two strategies that they felt were the most effective for engaging their students in the learning process in developmental mathematics, four of the nine strategies they described reflected the research-based strategies as recommended by AMATYC (2006): Collaborative/Cooperative Learning, Interactive Lecturing, Question-Posing, and Writing. Thus, 30% of the developmental mathematics instructors from all 13 of Missouri’s 2-year public CCs indicated they are already implementing some of the recommended instructional strategies that promote active learning according to AMATYC (2006). The instructional strategies they also described included: Use of Textbook Problems, Use of Real-World Problems, Enthusiasm/Encouragement, Computer-Assisted Technology, and Working One-on-One With Students.

These strategies the instructors suggested as ways for engaging students may not have been specifically recommended in the strategies by AMATYC (2006), however they
were recommended by multiple instructors in the survey. For example, the use of textbook problems was described as a way of having students actively work through the problems, whether it was by having individuals solving the problems at their seats, solving a problem together as a group at the board, or by sending individuals to the board to work on problems. Additionally, the use of real-world problems in a developmental mathematics class is an approach instructors like to use to get students motivated in the mathematics they are learning. One instructor described it (in the survey) this way:

The most effective strategy I have found is to apply the math to authentic situations. Everyone hears the question, “When will I ever use this?” and I continue to hear it in my Elementary Algebra class. When you actually have a solid answer and examples for when they use it in life they are more eager to understand and master the concept. They realize it is not just busy work.

According to Mesa (2010), the type of curriculum and instruction that is implemented can have a significant impact on the motivation of adults learning mathematics: “The literature documents the need for realistic mathematics curriculum and for instructional approaches that honor what students bring into the classroom: their academic, personal, and work experiences” (p. 65).

With respect to the instructional strategy of enthusiasm/encouragement, one instructor recommended that one should, “develop a classroom environment where students are encouraged and feel safe to make guesses, ask questions, and just try what feels right.” Another instructor stated (in the survey) that,

Another effective strategy is simply showing enthusiasm for the material…Making it comfortable and fun in the classroom through simple
conversation makes students feel like they can open up more, ask questions, and not be rejected. This is huge in making sure students are really a part of the class and the learning process.”

Mesa et al. (2014) found that a group of remedial mathematics instructors she studied, “tended to describe the need for improving self-confidence and developing relationships” with their students (p. 136). The goal for the instructors was to quell their fear of math.

Furthermore, when asked to describe two strategies that instructors feel are most effective for engaging their students in the learning process in developmental mathematics, many recommended the use of computer-assisted technology. Thus, because the use of MyMathLab and ALEKS has become an integral part of the curriculum, many instructors included these as one of the ways to engage students in the learning process. Additionally, many instructors indicated in the survey they were using the Emporium Model in their developmental mathematics classes, where part of the classroom time is spent in a lab in which students work on a computer.

The Emporium Model is designed for mastery learning in which the instruction is presented online in lecture videos, homework problems, quizzes, and tests (personal communication, Prof. Buster, November 2014). According to NCAT (2010), “the Emporium Model makes significant shift in the teaching-learning enterprise, making it more active and learner-centered” (p. 2). Lectures are replaced with an assortment of interactive activities and materials that require students to be more than passive learners; students end up learning math by doing math. Instructional software and web-based resources, such as MyMathLab and ALEKS play an important role in engaging students
in the course content (NCAT, 2010). These resources provide frequent practice and feedback of course concepts through tutorials, exercises, and quizzes.

Another positive aspect to the Emporium Model is that it “replaces lecture time with individual and small-group activities that take place in computer labs – staffed by instructors, professional tutors, and/or peer tutors – and/or online, enabling students to have more one-on-one assistance” (NCAT, 2010, p. 3). This might explain the addition of working One-on-One with students as a strategy for engaging their students in the learning process in developmental mathematics. As one instructor described it, “Take time EVERY class to sit down with EVERY student, to gauge their progress, help with any mathematical or time-management issues, and encourage them to continue.” In order to be able to visit with every student, it would stand to reason that this instructor, as well as many other instructors who chose this strategy, had the advantage of the Emporium Model to be able to do this.

These strategies the instructors suggested as ways for engaging students may not have been specifically recommended in the strategies by AMATYC (2006), however, they were recommended by multiple instructors in the survey. These strategies included: Use of Textbook Problems, Use of Real-World Problems, Enthusiasm/Encouragement, Computer-Assisted Technology, and Working One-on-One With Students. Because of their importance to the instructors in this survey the developmental mathematics education research community may want to assess these instructional strategies for engaging students in the learning process for their viability.

**Instructional Strategies Rated as Important and Those Initially Described**
There was an interesting observation I made when instructors were asked to rate the importance of given instructional strategies from AMATYC (2006) when you compare these answers to those instructional strategies used to promote active learning they previously described. The initial descriptions that matched up with the AMATYC (2006) strategies were Collaborative/Cooperative Learning (employing pairs & small groups of students), Interactive Lecturing (responding to any answer given & use of teacher-created note packets), Question-Posing (using guiding questions & activities to develop conceptual understanding), and Writing (taking notes/keeping track of important mathematics ideas).

The other highly rated strategies never mentioned in the initial teacher descriptions, however, were the Discovery-Based Learning strategies, which involved using student answers to guide classroom discussions and presenting examples that lead to patterns, forming the basis of mathematical rules. The instructors also indicated that they had implemented these strategies. One of the instructors who I observed, Prof. Buster, did implement discovery-based learning strategies in her lessons.

The question becomes do the instructors truly understand what Discovery-Based Learning is and how to implement it? According to AMATYC (2006) discovery-based learning involves instructors to employ the use of carefully designed questions and activities in order that students can be led to connect new knowledge to prior knowledge. For some students, teachers may be required to utilize additional questions to help students to construct knowledge.

It may seem obvious that students must think in order to learn, as Thompson and Zeuli (1999) argue, “The idea that students must create their own understandings by
thinking their way through to satisfactory resolutions of puzzles and contradictions runs counter to conceptions of knowledge as facts, teaching as telling, and learning as memorizing” (p. 349). The dominant form of teaching has been telling in our culture, and such deeply rooted schemas do not go away easily. Thinking to learn is different from learning to think, and this reformed practice of teaching in mathematics is what needs to be changed in order for discovery-based learning or constructivist type of learning to take place in the classroom.

The two instructional strategies that were rated the lowest in importance given in the survey were also the same strategies that instructors were not interested in implementing. They included the Collaborative/Cooperative Learning strategy specific to assigning Internet group projects and the Writing strategy specific to asking students at the beginning of class to write about what they learned from doing the homework. What one instructor stated in the survey about the Internet group projects represented many others’ responses on the survey:

I would not use Internet group projects for developmental mathematics for several reasons: 1) most of my students do not have reliable Internet access due to their economic situations; 2) I teach night classes and most of my students are non-traditional students with full-time employment during the day – they are sometimes not internet-proficient, nor do they have extra time to coordinate schedules for group work outside of class; and 3) I have found in the past that Internet group projects are just a copy-paste exercise in plagiarism from other websites – I don’t like awarding zero credit due to cheating, inadvertent or otherwise.
Many instructors in the survey had similar responses to this respondent, stating that their students only had Internet access at the community college and did not have extra time for group projects outside of class due to family and job commitments.

With respect to asking students to write about what they learned from the homework at the beginning of class, an instructor from the survey responded, “I find little to no value in this exercise. Students at this level of math often don’t truly see what they have learned from their homework…Often I’ll ask students in class, ‘How does this connect with what we did last class session?’ This is more pertinent than, ‘What did you learn from doing homework’”. Other respondents stated that their students would feel like writing about what they learned about homework would be busy work. The instructors also stated they felt they could be using the class time in more purposeful ways than asking the students to write about what they learned from the homework. From these responses, one can see the instructors need some method of support to make the implementation of this instructional strategy more feasible.

**Instructional Strategies Observed and the Cognitive Complexity Involved**

The three instructors who indicated a high usage of instructional strategies to promote active learning on the survey, I found actually employed many of these strategies within their lessons when I observed them. As stated earlier, use of Real-World Problems, use of Textbook Problems, Enthusiasm/Encouragement, Collaborative/Cooperative learning, Interactive Lecturing, Question-Posing, Writing, and Discovery-Based Learning strategies were used. Not only was I able to document the implementation of these strategies while observing the lessons, but also I was able to determine the cognitive complexity of the tasks and questions used during the
implementation of the strategies, in order to assess the quality of mathematics instruction (Mesa et al., 2014).

As previously mentioned 60% of the tasks employed were procedures without connections, which is considered a lower-level cognitively demanding activity (Stein, Smith, Henningsen, & Silver, 2009). On a positive note, 40% of the tasks employed were procedures with connections, which is considered a higher-level cognitively demanding activity. In this case, the tasks instructors chose to implement to engage students in the learning process (through their instructional strategies) were tasks of higher-level demand. However, none of the instructors chose to implement tasks of the highest-cognitive demand at level 4, doing mathematics. Could this suggest that there were not any level 4 tasks in the curriculum that these instructors used? Or because level 4 tasks “require considerable cognitive effort and may involve some level of anxiety for the student” (Smith & Stein, 1998, p. 348), the instructors avoided using these tasks? Students in developmental mathematics classes do have high anxiety levels towards the subject matter (Perin, 2013).

This study corroborated previous research found by Mesa (2010), who also studied developmental mathematics instructors, with respect to questioning. She discovered that “few activities required metacognitive knowledge or expected students to analyze, evaluate, or create” (p. 76). Additionally, the questions instructors implemented mainly centered on assisting students in remembering, understanding, and analyzing mathematics facts and procedures more frequently than engaging students in higher-order questions and tasks. My study had similar results with respect to the types of questions used by the developmental mathematics instructors I observed.
Support Needed to Implement Instructional Strategies

The information I obtained during the post-observation interviews concerning the support needed from those developmental mathematics instructors who participated in the case study supports the recommended professional development according to AMATYC (2006). All three case studies indicated they needed some support to do their jobs better. They all spoke of finding additional curriculum and instructional strategies to better support and explain the content to their students in their developmental mathematics courses. According to the professionalism guidelines in *Beyond Crossroads*, “New full-time and adjunct faculty especially need to be encouraged to participate in departmental activities, discussions of curricular and pedagogical issues, and decisions regarding textbook selection” (AMATYC, 2006, p. 65). Additionally, both FT and PT faculty should be involved in regular department meetings to discuss implementation of new or different instructional practices. For effective instructional change to occur, the college administration must be involved and committed in supporting the department’s goals and activities to provide a quality mathematics education for all students. If the community colleges’ mathematics departments want their instructors to break out of the traditional mode of teaching mathematics in a lecture style to developmental mathematics students, instructors will need some guidance.

In order to use these instructional strategies to engage their students in the learning process, the instructors’ realized they needed time to be able to get together with other developmental mathematics instructors to discuss their teaching strategies and to observe others’ teaching. According to the professionalism guidelines in *Beyond Crossroads*, “teaching should be viewed as a process of ongoing reflection and inquiry
that requires collegial exchange and openness” (AMATYC, 2006, p. 67). This includes implementing the following strategies: informal discussions among peers in which excellence in teaching is promoted; creating a website that could serve as a site for effective pedagogical strategies; and creating newsletters for fellow practitioners.

Finally, the last idea that resulted from the post-observation interviews was the need to procure funding and schedule more time for professional developmental for both full-time and part-time instructors. From the survey, I learned that twice as many FT instructors belonged to NCTM as PT instructors, with almost 3 times as many PT instructors belonging to MCTM as FT instructors. From there the comparison ends, because the majority of the memberships to the remaining professional societies were by FT instructors. We know that “participation in professional organizations and societies is critical for professional growth” (AMATYC, 2006, p. 66). Being in a professional organization gives instructors countless opportunities for professional development and networking with mathematics educators across the state and country. “Institutions can be proactive in providing internal funding, released time for faculty to pursue projects or attend professional meetings, and substitutes for missed classes” (AMATYC, 2006, p. 66). Because of the low salary base PT instructors are already working with they are less likely to spend precious money on membership in a professional society. Thus, if community colleges feel it is important that their PT instructors stay informed on the latest instructional methods for engaging students in the learning process, they must find a way to support PT instructors in this endeavor.
Implications of the Study

This section will address key findings of this study, and the resulting implications. Four categories of implications have been identified from this study: (1) Reevaluation of the AMATYC (2006) Framework, (2) Offer PD on Discovery-Based Learning, (3) Offer PD on Cognitive Complexity of Mathematical Tasks and Questions, and (4) Support Needed to Implement Instructional Strategies.


When answering research questions one and two, I found the instructional strategies used to promote active learning given in the AMATYC (2006) framework may need to be reevaluated due to the misalignment of this document and the perceptions of my study’s participants. At the beginning of the survey when the developmental mathematics instructors in Missouri’s public 2-year colleges were asked to describe the instructional strategies they used to promote active learning, four of the nine strategies they described reflected the research-based strategies as recommended by AMATYC (2006) from Table 1, which included: Collaborative/Cooperative Learning, Interactive Lecturing, Question-Posing, and Writing. They also described the following instructional strategies that were not included in the AMATYC (2006) framework:

- Use of Textbook Problems (Frequency of 59 or 21%),
- Use of Real-World Problems (Frequency of 21 or 7%),
- Enthusiasm/Encouragement (Frequency of 32 or 11%),
- Computer-Assisted Technology (Frequency of 30 or 11%), and
- Working One-on-One With Students (Frequency of 25 or 9%).
Because of the significance of using real-life problems on the motivation of adult learners in mathematics (Mesa, 2010), and the use of enthusiasm and encouragement to help students improve self-confidence and develop relationships with the instructor and other students (Mesa, 2014), these strategies may be ones that might be included in some manner within the AMATYC (2006) framework. Additionally, due to the increased use of the Emporium Model in the instructors’ classes as indicated in the survey answers, the instructors’ favorably described computer-assisted technology and working one-on-one as instructional strategies for engaging students in the learning process. Thus, one implication of this study would be to suggest the inclusion of the use of Real-World Problems, Enthusiasm/Encouragement, Computer-Assisted Technology, and Working One-on-One With Students in some manner within the AMATYC (2006) framework of *Instructional Strategies That Promote Active Learning* (p. 54) or within the *Beyond Crossroads, Chapter 7 on Instruction* (AMATYC, 2006).

When instructors were asked to rate the importance of given instructional strategies from AMATYC (2006), there were two instructional strategies rated the lowest, which were also the strategies instructors indicated they were not interested in implementing. The instructors indicated the following strategies as barriers to implementation of best practice: Collaborative/Cooperative Learning strategy specific to assigning Internet group projects and the Writing strategy specific to asking students at the beginning of class to write about what they learned from doing the homework. The instructors had specific, legitimate reasons for why assigning Internet group projects did not work in developmental mathematics classrooms. Additionally, instructors gave reasons for not wanting to use the strategy of having students write about what they
learned from doing their homework at the beginning of class. Thus, another implication of this study would be suggesting that these two instructional strategies from the AMATYC (2006) framework of *Instructional Strategies That Promote Active Learning* (p. 54) be reevaluated in light of newer, contemporary research. Moreover, those in the field of developmental mathematics research may want to provide some mechanisms or methods of support for instructors to make the implementation of these two instructional strategies more acceptable.

**Offer PD on Discovery-Based Learning**

One of the instructional strategies that was listed in the AMATYC (2006) framework and developmental mathematics instructors rated as “Extremely Important” to “Very Important” was Discovery-Based Learning (present examples that lead to patterns) (Mean of 1.55). They also indicated they had implemented this strategy. However, in the survey question prior to this one in which they had to describe strategies they used to engage students in the learning process, this type of instructional strategy was not given. Therefore, the question becomes, are instructors really implementing this strategy since they did not describe it as one that they used to engage students in the learning process?

Fortunately, one of the instructors that I observed, Prof. Buster, did employ Discovery-Based Learning strategies. Hence, I can say there is at least one instructor, probably more in Missouri implementing this strategy. My recommendation would be to ask Prof. Buster to do a workshop using some of the discovery-based learning techniques she is using in her classroom at a MOMATYC conference. She told me that has presented at conferences before, so I know she would be comfortable doing this. One obstacle that
would have to be overcome, though is that most of the PT instructors are not members of MOMATYC, thus would not attend this statewide conference.

**Offer PD on Cognitive Complexity of Mathematical Tasks and Questions**

I found it positive that the developmental mathematics instructors who participated in the survey indicated they used many of the instructional strategies that promote active learning as recommended by AMATYC (2006). Additionally, of the three instructors I chose to observe who indicated a high use of instructional strategies to promote active learning on the survey, I did find they actually employed many of these strategies. When I determined the cognitive complexity of the tasks and questions used during the implementation of the strategies, I found mixed results.

On a positive note, 40% of the tasks employed were procedures with connections, which is considered a higher-level cognitively demanding activity, requiring more student engagement (Stein, et al., 2009). Thus, almost half the tasks instructors chose to implement to engage students in the learning process (through their instructional strategies) were tasks of higher-level demand. The questions posed by instructors, were much less cognitively demanding. Instructors’ questions mainly centered on assisting students in remembering, understanding, and analyzing mathematics facts and procedures. The implication is here is that the cognitive complexity of tasks and questions will not change unless instructors become aware of how to reflect and analyze their own teaching. I would recommend offering some PD to developmental mathematics instructors on how to analyze the cognitive demand of mathematics tasks by using *The Task Analysis Guide* created by Smith and Stein (1998, p. 348). Additionally, I would also recommend offering some PD on how to analyze questions using the revised
taxonomy that I created, *Framework for Determining Cognitive Level of the Types of Questions Used in Mathematics Teaching* (Table 3).

**Support Needed to Implement Instructional Strategies**

All the developmental mathematics instructors involved in the case studies spoke of searching for additional curriculum and active learning instructional strategies to better support and explain the content to their students in their developmental mathematics courses. The implication here is, if the MDHE wants effective instructional change to occur, then community college administrations need to be involved and committed in supporting their department’s goals and activities to provide a quality mathematics education for their students. If MDHE wants developmental mathematics instructors to break out of the traditional mode of teaching mathematics and explore employing alternate delivery methods, then instructors will need guidance.

In order to use these instructional strategies to engage their students in the learning process, the instructors’ indicated they need time to get together with other developmental mathematics instructors to discuss their teaching strategies and to observe others’ teaching. Recommendations from AMATYC (2006) include: having informal discussions among peers in which excellence in teaching is promoted; creating a website that could serve as a site for effective pedagogical strategies; and creating newsletters for fellow practitioners.

Finally, from this study we learned that the majority with memberships to professional societies were held by FT instructors. The implication here is that we must find a way to help more PT instructors hold memberships in professional societies. Being in a professional organization gives instructors countless opportunities for professional
development and networking with mathematics educators across the state and country. MDHD and 2-year community colleges should be proactive in providing internal funding, release time so that FT and PT faculty can pursue projects and/or attend professional meetings, as well as provide substitutes for missed classes (AMATYC, 2006).

**Limitations of the Study**

An explanatory sequential mixed method design posed a few challenges for me as the researcher, because of the amount of time it took to implement two separate phases (Creswell & Clark, 2011). The amount of time it took to obtain the needed IRBs and permissions from all of the individual community colleges took longer than expected, delaying the start of the survey, which in turn delayed access to the names of those who might participate in the case studies. Additionally, analyzing the data for the qualitative phase did take more time than the quantitative phase, and I had to be mindful of that when budgeting my time to complete this research project.

Another limitation of this study is that all of the data collected from the survey were self-reported data from community college instructors in the state of Missouri. Although they did describe their own instructional practices in the first survey question using their own words, they may have overestimated their use of instructional strategies that promote active learning in the subsequent survey questions in which they could select from a given list. These data can be trusted however, because there is no incentive for the instructors to not be truthful. The instructors also indicated strategies they never used, knowing that I had no authority or control over them, so there was no reason to be deceitful.
A final limitation was the number of participants that I chose to use for my case studies. If I had more time for this research study I would have chosen to observe more developmental mathematics instructors so as to have seen more diversity in the types of instructional strategies implemented. Moreover, I chose to observe instructors who indicated a high usage of instructional strategies to promote active learning on the survey to document whether instructors were actually employing the strategies they indicated they were using. For this study this was effective, however, I do not believe these three instructors would be a good indicator as a sample of the overall population because of the high use of instructional strategies they indicated on the survey and employed in the classroom. Another limitation with respect to the case studies was that I only visited the classrooms three times. While this gave me some understanding of how the participants taught, this was still a limited amount of time, thus affecting the persistent observation or credibility of the study (Lincoln & Guba, 1985).

**Recommendations for Future Research**

This study found that developmental mathematics instructors in Missouri were using alternative forms of instruction to engage students in the learning process. The next step to go forward in this research would be to document whether or how student learning is affected by the implementation of these instructional strategies that promote active learning. Because the instructional strategy with the highest frequency described by developmental mathematics instructors for engaging students in the learning process was Collaborative/Cooperative Learning, this strategy should be used in going forward with future research. The instructors also indicated the most established methods of implementing Collaborative/Cooperative Learning was by having students solve textbook
problems together, explain the problems to each other, and discuss the solutions with each other. Johnson, Johnson, and Smith (1998) have techniques and recommendations for implementing cooperative learning in the college classroom that would be helpful for a project like this. Like in this study, the tasks used and/or the questions used should be analyzed for their cognitive complexity to build on this research. According to Mesa et al., (2014), “there is little research on the factors associated with mathematical instruction that can be directly related to retention and success in community colleges” (p. 119).

Future research on professional development that could be provided to developmental mathematics instructors to help them create opportunities in their classrooms to increase the cognitive complexity in both the tasks implemented and questions asked would be very important. *The Task Analysis Guide* created by Smith and Stein (1998) to analyze the cognitive demand of tasks is still unknown to many mathematics educators. Likewise, many instructors may have heard of the revised Bloom’s taxonomy, but may not have thought to analyze their questioning techniques with respect to this taxonomy. Furthermore, I am unaware how many instructors are familiar with the question types recommended by NCTM (2014). Thus, future research is needed on the type of professional development that would best meet the needs of developmental mathematics instructors who want to create the opportunity for students to engage in higher-level tasks and questions. Should MDHE be responsible for training the department chairs at the community colleges, who would then take the information to their instructors? How should this important information be disseminated to the instructors?
Finally, additional research should also investigate whether PT developmental mathematics instructors would take advantage of participating in professional development and/or becoming a member of a professional society if given the means to do so. What resources would they take advantage of? Does their degree background influence their attitude about participation in mathematics education specific professional development? Would they be interested in reading professional articles specific to mathematics teaching?

**Final Thoughts**

The purpose of this study was to explore and describe the instructional strategies used to engage students in the learning process by developmental mathematics instructors in Missouri’s public 2-year colleges. Additionally, this study sought to analyze the cognitive levels of the mathematics tasks and questions implemented in the instructional strategies, because research indicates student learning is greatest in those classrooms where the tasks and discourse routinely engage students in high-level thinking and reasoning (NCTM, 2014). The instructors in this study indicated that they used instructional strategies that could promote active learning, and a small sample was observed implementing these instructional strategies. Work still needs to be done to help instructors engage students in higher-level thinking and reasoning in both mathematical tasks and discourse.

This study illuminated a difference between FT and PT instructors’ participation in professional societies, and thus their professional development behaviors. The information gleaned from the case studies in particular, suggests that funding needs to be procured to provide professional development opportunities for PT instructors.
REFERENCES


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APPENDIX A: APPROVAL LETTER FROM HUMAN SUBJECTS IRB AT THE UNIVERSITY OF MISSOURI

August 29, 2014

Principal Investigator: Spain, Vickie L
Department: Learning Teaching & Curriculum

Your Application to project entitled Active Learning Strategies Employed by Developmental Mathematics Instructors in Missouri Public Community Colleges and the Cognitive Levels of the Mathematical Tasks and Questions Implemented in the Instructional Strategies was reviewed and approved by the MU Campus Institutional Review Board according to terms and conditions described below:

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<tr>
<th>IRB Project Number</th>
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<tbody>
<tr>
<td>Funding Source</td>
<td>None</td>
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<tr>
<td>Initial Application Approval Date</td>
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<td>IRB Expiration Date</td>
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The principal investigator (PI) is responsible for all aspects and conduct of this study. The PI must comply with the following conditions of the approval:

1. No subjects may be involved in any study procedure prior to the IRB approval date or after the expiration date.
2. All unanticipated problems, serious adverse events, and deviations must be reported to the IRB within 5 days.
3. All modifications must be IRB approved by submitting the Exempt Amendment prior to implementation unless they are intended to reduce risk.
4. All recruitment materials and methods must be approved by the IRB prior to being used.
5. The Annual Exempt Form must be submitted to the IRB for review and approval at least 30 days prior to the project expiration date.
6. Maintain all research records for a period of seven years from the project completion date.
7. Utilize the IRB stamped document informing subjects of the research and other approved research documents located within the document storage section of eIRB.

If you have any questions, please contact the Campus IRB at 573-882-9585 or umcresearch@irb@missouri.edu.

Thank you,

Charles Borodin, PhD
Campus IRB Chair
APPENDIX B: INITIAL LETTER TO PRESIDENTS AND CHIEF ACADEMIC OFFICERS

Dear (Presidents and Chief Academic Officers of each Missouri Community College/ and identified remedial/developmental department chairs):

As the Fall Semester quickly approaches, we could really use your assistance and support with an outstanding doctoral dissertation study.

I am working with Vickie Spain, a Mizzou math education doctoral candidate, who is studying teaching strategies, which promote active learning in remedial/developmental math instruction in Missouri community colleges.

At the beginning of September, Vickie would like to survey your FT and PT remedial/developmental math instructors (limited to Basic Math/Pre-Algebra, Elementary Algebra and Intermediate Algebra—which are courses normally numbered “100 and below”.)

Vickie’s confidential Internet survey will ask participants to:

- Describe active learning strategies used in developmental mathematics classes;
- Rate the importance of various active learning teaching strategies; (recommended by the American Mathematical Association of Two-Year Colleges—AMATYC) and
- Designate staff development training needs.

During the Fall Semester, Vickie may request permission to personally observe one or two of your remedial/developmental math instructors in their classroom(s) who are actually using active learning fundamentals.

Is there a way you could please forward this message and supply Vickie and myself with the name and contact information of your campus remedial/developmental department chair/head/division director, and give us permission to contact them to develop a survey directory?

Vickie and I will be happy to talk with you by telephone to help clarify her research. She can be reached at:

Vickie Spain
119 Townsend Hall
University of Missouri—Columbia
vls76@mail.missouri.edu
573-999-0560 (cell)
Thank you so much.

Terry

Terry Barnes PhD
Assist. to the Provost for Community College Partnerships
Office of the Provost
University of Missouri in Columbia
180 I General Services Bldg.
Columbia, MO 65211
Office (573) 884-2223
Cell (573) 631-9451
Fax (573) 882-0080
e-mail: barneste@missouri.edu
October 3, 2014

To Whom It May Concern:

This letter is to verify that Vickie Spain, a PhD candidate at the University of Missouri, has permission from Moberly Area Community College (MACC) to proceed with her research project entitled “Active Learning Strategies Employed by Developmental Mathematics Instructors in Missouri Public Community Colleges and the Cognitive Levels of the Mathematical Tasks and Questions Implemented in the Instructional Strategies.” As part of her research, Ms. Spain has permission from MACC to observe and interview two MACC instructors as well as make audio-tapes and take field notes during classroom observations.

MACC does not perceive any risks to our instructors or students and considers Ms. Spain to have the same level of approval from MACC as she does from the University of Missouri in conducting her research.

Sincerely,

Paula Glover, PhD
Vice President for Instruction

Moberly Area Community College
101 College Avenue
Moberly, MO 65270-1304
Phone (660) 263-4100
Website www.macc.edu
Jeffery C. Lashley, Ph.D., President
Date: October 7, 2014

To: Dean Wilcoxson

From: Vernon Kays

Subject: Classroom observation request

To Whom It May Concern:

This letter is to verify that Vickie Spain, a PhD candidate at the University of Missouri, has permission from St. Louis Community College (STLCC) to proceed with her research project entitled "Active Learning Strategies Employed by Developmental Mathematics Instructors in Missouri Public Community Colleges and the Cognitive Levels of the Mathematical Tasks and Questions Implemented in the Instructional Strategies." As part of her research, Mrs. Spain has permission from STLCC to observe and interview one of the STLCC instructors, Deborah Char, as well as make audio-tapes and take field notes during classroom observations.

STLCC does not perceive any risks to our instructors or students and considers Mrs. Spain to have the same level of approval from STLCC as she does from the University of Missouri in conducting her research.

Respectfully,

Dr. Vernon Kays
Academic Dean for Business and Communications
St. Louis Community College the Meramec Campus
11333 Big Bend Blvd.
Kirkwood, MO 63122-5799
(314) 984-7848
APPENDIX D: INTRODUCTORY LETTER FROM MYSELF

University of Missouri-Columbia

August 29, 2014

My name is Vickie Spain and I am a doctoral candidate in Mathematics Education at the University of Missouri Columbia. I am undertaking a research study concerning the instructional strategies used in developmental mathematics courses in Missouri public community colleges. I believe a study like this is timely because of the goal held by Missouri’s Department of Higher Education to identify instructional strategies used by faculty for preparing and retaining students in college-level courses.

The purpose of the survey for this research study is learn how instructors’ describe the instructional strategies they use, rate the importance of, and implement various instructional strategies that could be used to engage students in the learning process. Finally, instructors will be asked whether they need help in implementing instructional strategies to engage students in the learning process, so that it can be determined what types of professional development might be offered to support instructors.

Would you please complete this survey by **Friday, September 12, 2014**?

Thank you for taking your valuable time to partner with me and answer this short 15-minute survey.

Link to survey: ________________________________

Vickie Spain  
PhD Candidate  
University of Missouri  
vlsz76@mail.missouri.edu  
573-999-0560
APPENDIX E: ACTIVE LEARNING SURVEY

Participant Consent Form – SQ – 1

Consent Form to Participate in a Research Study

Researcher’s Name: Vickie Spain
Project Number: 1213112
Project Title: Active Learning Strategies Employed by Developmental Mathematics Instructors in Missouri Public Community Colleges and the Cognitive Levels of the Mathematical Tasks and Questions Implemented in the Instructional Strategies

Purpose of the Research:
The purpose of this research study is to identify the instructional strategies employed by developmental mathematics instructors to engage students in the learning process in Missouri’s public community colleges. How instructors describe the instructional strategies they use, as well as rate the importance of and implement various instructional strategies that could be used to promote active learning will be documented. Finally, instructors will be asked whether they need help in implementing instructional strategies to engage students in the learning process, so that it can be determined what types of professional development might be offered to support instructors.

What am I being asked to do? How long will it take?
Participation in this study involves answering a 13-question survey (15 min.). Additionally, for those who are willing and interested, this study will include three classroom observations by myself in one of your developmental mathematics classes. During the observations you will be audio-recorded. A post-observation interview will be conducted after each class, which may take between 30-45 minutes.

What are the benefits of being in this study?
Participants may gain knowledge about instructional practices that can be used to engage students in the learning process. This study has the potential to inform those in the Missouri Department of Higher Education of the types of professional development that would be beneficial to developmental mathematics instructors in both two-year and four-year institutions.

What are the risks of being in the study?
There are no known risks to those participating in the survey. There may be minimal risks to those who choose to participate in the observation component, which may involve discomfort by being observed or responding to the post-observation questions.

Confidentiality
Your name and institution will be kept completely confidential. Information produced by this study will be stored in the investigator’s file and identified by a pseudonym only. The key connecting your pseudonym to specific information about you will be kept in a secure location. Information contained in your records may not be given to anyone unaffiliated with the study in a form that could identify you without your written consent, except as required by law.

Freedom to Withdraw
You are free to decide not to participate in this study or to withdraw at any time without adversely affecting your relationship with the investigator or your institution.

Consent, Right to Receive a Copy
You are voluntarily making a decision to participate in this research study. Your participation in this survey serves as your consent to the survey. At the end of the survey is a question asking those participants willing and interested to allow me to be an observer in one of their developmental mathematics classes, to provide their contact information. A post-observation interview will be conducted after each class.

Who do I contact if I have questions, concerns, or complaints?
Vickie Spain
PhD Candidate
University of Missouri
SQ – 2

For this study, developmental mathematics is defined as mathematics coursework in higher education that is designed to prepare students for entrance into and the study of college-level mathematics.

Describe two strategies you feel are the most effective for engaging your students in the learning process in developmental mathematics.
**SQ – 3**

Rate how important you feel the following teaching strategies are for use in a developmental mathematics classroom.

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Extremely Important</th>
<th>Very Important</th>
<th>Important</th>
<th>Not Very Important</th>
<th>Not Important at All</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provide pairs or small groups of students the opportunity to work together to explain a problem, interpret a graph, review another student's work, discuss the correct solution, or engage in a project.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td></td>
</tr>
<tr>
<td>Assign internet group projects (in or out of class) or technology activities.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td></td>
</tr>
<tr>
<td>Ask students to work in pairs on a homework problem before class begins.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td></td>
</tr>
<tr>
<td>Use student answers to guide classroom discussion.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td></td>
</tr>
<tr>
<td>Present examples that lead to patterns, which form the basis of mathematical rules.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td></td>
</tr>
<tr>
<td>Respond to any answer given (right or wrong) and discuss the logical ramifications of trying to solve the problem using alternative methods.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td></td>
</tr>
<tr>
<td>Ask questions to guide students to solutions of problems.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td></td>
</tr>
<tr>
<td>Engage students in activities that lead them to develop conceptual understandings.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td></td>
</tr>
<tr>
<td>Ask students to write questions that require explanations.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td></td>
</tr>
<tr>
<td>Ask students at the beginning of class to write about what they learned from doing the homework.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td></td>
</tr>
<tr>
<td>Encourage students to take notes and/or keep track of important mathematics ideas and problem statements by writing a checklist on the board or disseminating a fact sheet.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td></td>
</tr>
<tr>
<td>Include a writing component in homework, student projects, investigation, and explorations of mathematical concepts.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td></td>
</tr>
</tbody>
</table>
SQ – 4

Describe your implementation of the following instructional strategies.

<table>
<thead>
<tr>
<th>Provide pairs or small groups of students the opportunity to work together to explain a problem, interpret a graph, review another student’s work, discuss the correct solution, or engage in a project.</th>
<th>Have Implemented this Strategy</th>
<th>Have Not Implemented</th>
<th>Plan to Implement in the Future</th>
<th>Not Interested in Implementing</th>
<th>Need Help Implementing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assign Internet group projects (in or out of class) or technology activities.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ask students to work in pairs on a homework problem before class begins.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use student answers to guide classroom discussion.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Present examples that lead to patterns, which form the basis of mathematical rules.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respond to any answer given (right or wrong) and discuss the logical ramifications of trying to solve the problem using alternative methods.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ask questions to guide students to solutions of problems.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engage students in activities that lead them to develop conceptual understandings.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ask students to write questions that require explanations.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ask students at the beginning of the class to write about what they learned from doing the homework.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Encourage students to take notes and/or keep track of important mathematical ideas and problem statements by writing a checklist on the board or disseminating a fact sheet.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Include a writing component in homework, student projects, investigations and explorations of mathematical concepts.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SQ – 5

Which of the instructional strategies previously listed would you use to engage students in the learning process when teaching a developmental mathematics course? Please explain.

SQ – 6

Which of the instructional strategies previously listed would you NOT use to engage students in the learning process when teaching a developmental mathematics course? Please explain.
SQ – 7

Which of the instructional strategies previously listed would you use to engage students in the learning process when teaching a credit-bearing college-level mathematics course (e.g. College Algebra, Statistics, or above)? Please explain.


SQ – 8

Which of the instructional strategies previously listed would you NOT use to engage students in the learning process when teaching a credit-bearing college-level mathematics course (e.g. College Algebra, Statistics, or above)? Please explain.


SQ – 9

Please list the course textbooks you are currently using for your developmental mathematics courses?

<table>
<thead>
<tr>
<th>Course, (Pre-Algebra, Elementary Algebra, or Intermediate Algebra)</th>
<th>Textbook 1</th>
<th>Textbook 2</th>
<th>Textbook 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Author(s)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Publisher</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


SQ – 10

What is your work status at the institution where you currently work?

- Full-time
- Part-time
**SQ – 11**

Please select the types of institutions you have taught at and list the number of years at each.

<table>
<thead>
<tr>
<th>Institution</th>
<th>Taught at This Type of Institution?</th>
<th>Total Number of Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elementary School (K-5)</td>
<td>○</td>
<td></td>
</tr>
<tr>
<td>Middle School/Junior High (Grades 6-8)</td>
<td>○</td>
<td></td>
</tr>
<tr>
<td>High School (Grades 9-12)</td>
<td>○</td>
<td></td>
</tr>
<tr>
<td>Two-Year College</td>
<td>○</td>
<td></td>
</tr>
<tr>
<td>Four-Year College</td>
<td>○</td>
<td></td>
</tr>
<tr>
<td>Four-Year University</td>
<td>○</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>○</td>
<td></td>
</tr>
<tr>
<td>None of the above</td>
<td>○</td>
<td></td>
</tr>
</tbody>
</table>

**SQ – 12**

Which of the following degrees have you completed? Choose all that apply.

- [ ] Bachelors in Mathematics
- [ ] Bachelors in Math Education
- [ ] Bachelors in Statistics
- [ ] Bachelors in Education or some other non-math education-related field (e.g. Physics Ed or Ed Tech)
- [ ] Bachelors in a math-related science (e.g. Physics, Chemistry, Engineering)
- [ ] Bachelors in a math-related business field (e.g. Economics, Finance)
- [ ] Bachelors in some field not directly listed here
- [ ] Masters in Mathematics
- [ ] Masters in Math Education
- [ ] Masters in Statistics
- [ ] Masters in Education or some other non-math education-related field (e.g. Physics Ed or Ed Tech)

(SQ – 12 continued on next page)
☐ Masters in a math-related science (e.g. Physics, Chemistry, Engineering)
☐ Masters in a math-related business field (e.g. Economics, Finance)
☐ Masters in some field not directly listed here
☐ Ph.D. in Mathematics
☐ Ph.D. or Ed.D in Math Education
☐ Ph.D. in Statistics
☐ Ph.D. or Ed.D. in Education or some other non-math education-related field (e.g. Physics Ed or Ed Tech)
☐ Ph.D. in a math-related science (e.g. Physics, Chemistry, Engineering)
☐ Ph.D. in a math-related business field (e.g. Economics, Finance)
☐ Other, please specify

SQ – 13

Check the following professional societies you are a current member of or have been a past member.

<table>
<thead>
<tr>
<th>Society</th>
<th>Yes</th>
<th>Past Member</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCTM (National Council of Teachers of Mathematics)</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>MCTM (Missouri Council of Teachers of Mathematics)</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>AMATYC (American Mathematics Association of Two-Year Colleges)</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>MOMATYC (Missouri Mathematics Association of Two-Year Colleges)</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>AMS (American Mathematical Society)</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>MAA (Mathematical Association of America)</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>MCCA (Missouri Community College Association)</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

SQ – 14

If there are other professional societies for you are a member, please list them below.

[Box to list other societies]
Would you be willing and interested in allowing me to observe the instructional strategies you use to engage your students in your developmental mathematics courses? Your name and institution will be kept completely confidential.

- Yes
- Maybe
- No

SQ – 16

Please include your contact information so that I may contact you about the classroom observations.

<table>
<thead>
<tr>
<th>Contact Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
</tr>
<tr>
<td>Institution</td>
</tr>
<tr>
<td>Email</td>
</tr>
<tr>
<td>Phone Number</td>
</tr>
</tbody>
</table>

Thank you for participating in the survey!

If you would like a summary of my findings, please contact me at:

Vickie Spain
University of Missouri
vlsz76@mail.missouri.edu
573-999-0560
APPENDIX F: CONSENT FORM TO PARTICIPATE IN THE RESEARCH STUDY

CONSENT FORM TO PARTICIPATE IN A RESEARCH STUDY

Researcher’s Name: Vickie Spain, M.Ed.
Project Number: 1213112

Project Title: Active Learning Strategies Employed by Developmental Mathematics Instructors in Missouri Public Community Colleges and the Cognitive Levels of the Mathematical Tasks and Questions Implemented in the Instructional Strategies

This consent may contain words that you do not understand. Please ask the investigator or the study staff to explain any words or information that you do not clearly understand.

INTRODUCTION

You are being asked to participate in a research study. This research is being conducted to learn about the instructional strategies developmental mathematics instructors use to engage students in the learning process. When you are invited to participate in research, you have the right to be informed about the study procedures so that you can decide whether you want to consent to participation.

You have the right to know what you will be asked to do so that you can decide whether or not to be in the study. Your participation is voluntary. You do not have to be in the study if you do not want to. You may refuse to be in the study without penalty. If you do not want to continue to be in the study, you may stop at any time without penalty or loss of benefits to which you are otherwise entitled.

WHY IS THIS STUDY BEING DONE?

The purpose of this study is to identify the instructional strategies employed by developmental mathematics instructors to engage students in the learning process in Missouri’s public community colleges. How instructors’ describe the instructional strategies they use, as well as rate the importance of and implement various instructional strategies that could be used to promote active learning will be documented. Finally, instructors will be asked whether they need help in implementing instructional strategies to engage students in the learning process, so that it can be determined what types of professional development might be offered to support instructors.

HOW MANY PEOPLE WILL BE IN THE STUDY?

Three instructors will take part in the case studies. You have been selected as a possible participant in this study because you expressed an interest and a willingness to
be involved in this project, as well as indicating on the survey that you use instructional strategies to engage students in the learning process.

WHAT AM I BEING ASKED TO DO? HOW LONG WILL IT TAKE?

Participation in this study involves researcher observation of three class periods of one of your developmental mathematics classes in the Fall of 2014. The observations of the classes will be audio recorded. During these observations, you may conduct your class in a business-as-usual manner and you will be asked to participate in a 30-45 minute interview following each observed lesson. The observations will focus on the use of the instructional strategies used to engage students in the learning process in the lesson. Overall, your commitment will involve less than 6 hours of time and will conclude by December of 2014. You can stop participating at any time without penalty.

WHAT ARE THE BENEFITS OF BEING IN THE STUDY?

It is likely that you will gain additional knowledge or understanding of instructional strategies that can be used to engage students in the learning process, which may be beneficial in terms of preparing and retaining students for enrollment in college-level mathematics courses.

WHAT ARE THE RISKS OF BEING IN THE STUDY?

There are only minimal foreseeable risks associated with participation in this study. The potential risks involve discomfort that you may feel in your responses to interview questions or in being observed during your classroom instruction.

WHAT ARE THE COSTS OF BEING IN THE STUDY?

There is no cost to you.

WHAT OTHER OPTIONS ARE THERE?

You may opt to not participate in this study, and will not be penalized for your decision.

CONFIDENTIALITY

Information produced by this study will be stored in the investigator’s file and identified by a pseudonym only. The key connecting your pseudonym to specific information about you will be kept in a secure location. Information contained in your records may not be given to anyone unaffiliated with the study in a form that could identify you without your written consent, except as required by law.

Audio recordings taken during the study that could identify you will not be used without your special written permission. In that case, you will be given the opportunity to
view or listen, as applicable, to the audio recordings before you give your permission for their use if you so request.

WHAT ARE MY RIGHTS AS A PARTICIPANT?

Participation in this research project is completely voluntary. You have the right to say no, and if you agree to participate, you have the right at any time to change your mind and withdraw. At any time, you may refuse to participate in certain procedures or answer certain questions without penalty or loss of benefits. You will be told of any significant findings that develop during the course of the study that may influence your willingness to continue to participate in the research.

WHO DO I CONTACT IF I HAVE QUESTIONS, CONCERNS, OR COMPLAINTS?

If you have concerns or questions, please contact the researcher:

Vickie Spain, M.Ed.
PhD Candidate
Department of Learning, Teaching, & Curriculum
119 Townsend Hall
University of Missouri
Columbia, MO 65211
vlsz76@mail.missouri.edu, (573) 999–0560

If you have any questions regarding your rights as a participant in this research and/or concerns about the study, or if you feel under any pressure to enroll or to continue to participate in this study, you may contact the University of Missouri Campus Institutional Review Board (which is a group of people who review the research studies to protect participants’ rights) at (573) 882-9585 or umcresearchcirb@missouri.edu.

A copy of this Informed Consent form will be given to you before you participate in the research.

SIGNATURES

I have read this consent form and my questions have been answered. My signature below means that I do want to be in the study. I know that I can remove myself from the study at any time without any problems.

Participant Signature ________________________________ Date ________________

Participant Printed Name ________________________________
APPENDIX G: CLASSROOM OBSERVATION PROTOCOL

The purpose of the observation is for the investigator to document the instructional strategies used by the developmental mathematics instructor to engage students in active learning. A new observation protocol should be used for each observation.

Investigator: ___________________________ Date of Visitation: ___________________________
Instructor: ___________________________ Institution: ___________________________
Course: ___________________________ Time of Lesson: ___________________________
Textbook: ___________________________ Textbook pages: ___________________________
Number of students present: ___________ Seated: Individually Pairs Groups of ____ (indicate #)

Record the instructional strategies used to engage students in the learning process, including the mathematical tasks and questions posed. Include a time stamp every 4-5 minutes. Write about:

- The instructional strategies used during the class.
- The questions the teacher posed.
- The mathematics tasks the teacher presented to the students such as, exercises/examples being worked/discussed in class on the board, and/or from their books or worksheets.
- Use of any instructional materials (by teacher or students), such as manipulatives, technology, or worksheets.
- How students are grouped and the expectations of students while in their groups.
- Out-of-class assignments whenever possible.

<table>
<thead>
<tr>
<th>Time</th>
<th>Classroom Activities</th>
<th>AL Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Check if any of the following instructional strategies in the developmental mathematics courses are observed. Refer to the field notes and add the time stamp when this occurred. Provide a comment if needed to explain what was observed.

Table 1 – *Instructional Strategies That Promote Active Learning* (AMATYC, 2006, p.54).

<table>
<thead>
<tr>
<th>Instructional Strategy</th>
<th>Chk if Obs’d</th>
<th>Comments</th>
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<tbody>
<tr>
<td><strong>Collaborative/Cooperative Learning.</strong></td>
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<tr>
<td>Provide pairs or small groups of students the opportunity to play a mathematical game, solve a textbook problem, explain, engage in a research project, interpret a graph to another student, review another student’s work, discuss the correct solution, review and critique a video.</td>
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<tr>
<td>Assign Internet group projects (in or out of class), technology activities or activities where measurements are taken and analyzed.</td>
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<td>Facilitate informal study groups outside of class.</td>
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<td>Ask students to work in pairs on a homework problem before class begins.</td>
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<tr>
<td>Provide a location for group review before an upcoming test.</td>
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<tr>
<td><strong>Discovery-based Learning</strong></td>
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<tr>
<td>Use student answers to guide classroom discussion.</td>
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<tr>
<td>Present examples that lead to patterns, which form the basis of mathematical rules.</td>
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<tr>
<td>Ask students to discover concepts or patterns.</td>
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<tr>
<td><strong>Interactive Lecturing and Question-Posing</strong></td>
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<td>Ask students to raise their hand and selecting the 3rd or 4th hand for a response.</td>
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<tr>
<td>Ask students to solve a problem and then compare their processes and/or answer with a student nearby.</td>
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<tr>
<td>Respond to any answer given (right or wrong) and discuss the logical ramifications of trying to solve the problem using alternative methods.</td>
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<tr>
<td>Ask questions to guide students to solutions of problems.</td>
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<tr>
<td>Engage students in activities that lead them to develop conceptual understandings.</td>
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<td>Ask students to write questions that require explanations.</td>
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<tr>
<td><strong>Writing</strong></td>
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<tr>
<td>Ask students to write to an absent student, explaining the most important mathematics concept from the day’s lesson.</td>
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<tr>
<td>Ask students at the beginning of the class to write about what they learned from doing the homework.</td>
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<tr>
<td>Encourage students to take notes and/or keep track of important mathematics ideas and problem statements by writing a checklist on the board or disseminating a fact sheet.</td>
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<tr>
<td>Ask members of a group to describe how to perform mathematical processes integral to the mathematical concept.</td>
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<tr>
<td>Include a writing component in homework, student projects, investigation and explorations of mathematical concepts.</td>
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</table>
APPENDIX H: POST-OBSERVATION INTERVIEWS PROTOCOL

1st Interview:

Interviewer: __________________________ Date: __________________________

Instructor: ___________________________ Institution: _____________________

Introduction:

I want to thank you for taking the time to allow me to interview you today. The objective of this study is to identify the instructional strategies employed by developmental mathematics instructors to promote active learning. Thus, the purpose of this interview is to gather information about your thoughts concerning the instructional strategies you implement in your course to engage students in the learning process.

In this interview I will ask you ten questions pertaining to: your background teaching developmental mathematics courses; the types of strategies you used to engage your students in the learning process in today’s lesson; and what kind of support you feel you need or don’t need to help you engage your students. What we discuss will be recorded and later transcribed. The transcripts of today’s interview will be available in the near future. If you would like to read them, please contact me. Do you have any questions before we start?

Instructor’s Background Teaching Developmental Mathematics Courses:

1. Why/how did you get started teaching developmental mathematics courses?
2. What choice should teachers have with respect to whether or not they teach developmental mathematics?
3. What kind of training have you received for teaching developmental mathematics?

Types of Strategies Used to Promote Active Learning:

4. What types of instructional strategies do you think are most effective when teaching developmental mathematics students?
5. Do you use different instructional strategies when teaching developmental mathematics courses as compared to credit-bearing college-level mathematics courses?
6. What were your plans to get your students engaged in the learning process in today’s class?
7. How engaged do you think the students were in today’s class? Explain.
8. What types of instructional strategies did you use in today’s class to engage students in the learning process? (Ask the following questions about each instance.)
   Follow-Up: How did you choose the mathematics task you used?
   What kinds of questions did you intend to ask?

Support Needed for Teaching Developmental Mathematics:

9. What support did you use to help you create today’s lesson? (e.g. curriculum, colleagues, other?)
10. What type of instructional support do you feel would be helpful for you in designing or using instructional strategies to engage students in the learning process in today’s topic?
Introduction:

I want to thank you for taking the time to allow me to interview you again today. As I stated before, the objective of this study is to identify the instructional strategies employed by developmental mathematics instructors to promote active learning. Thus, the purpose of this interview is to gather more information about your thoughts concerning the instructional strategies you implement in your course to engage students in the learning process.

In this interview I will ask you ten questions pertaining to: the types of strategies you used to engage your students in the learning process in today’s lesson; and what kind of support you feel you need or don’t need to help you engage your students; and the use of the curriculum to engage students in the learning process. What we discuss will be recorded and later transcribed. The transcripts of today’s interview will be available in the near future. If you would like to read them, please contact me. Do you have any questions before we start?

Types of Strategies to Promote Active Learning:
1. What were your plans for getting your students engaged in the learning process in today’s lesson?
2. How engaged do you think the students were in today’s class? Explain.
3. What types of instructional strategies did you use in today’s class to engage students in the learning process? (Ask the following questions about each instance.)
   Follow-Up: How did you choose the mathematics task you used?
   What kinds of questions did you intend to ask?

Support Needed for Teaching Developmental Mathematics:
4. What support did you use to help you create today’s lesson? (e.g. curriculum, colleagues, other?)
5. What type of instructional support do you feel would be helpful for you in designing or using instructional strategies to engage students in the learning process in today’s topic?

Instructor’s Use of Curriculum to Engage Students in the Learning Process:
6. What textbook do you use for this course? How would you describe the curriculum?
7. What control do you have with respect to choosing the textbook you use for this course?
8. Where do the instructional activities you use to engage students in the learning process come from?
9. What characteristics are you looking for in a mathematics task when choosing a task to engage students in the learning process?
10. How would you describe the type of mathematics tasks you use in teaching developmental mathematics courses as compared to credit-bearing college-level mathematics courses?
3<sup>nd</sup> Interview:

Introducer: __________________________  Date: ______________________

Instructor: __________________________  Institution: ________________

Introduction:

I want to thank you for taking the time to allow me to interview you again today. As I stated before, the objective of this study is to identify the instructional strategies employed by developmental mathematics instructors to promote active learning. Thus, the purpose of this interview is to gather more information about your thoughts concerning the instructional strategies you implement in your course to engage students in the learning process.

In this interview I will ask you ten questions pertaining to: the types of strategies you used to engage your students in the learning process in today’s lesson; what kind of support you feel you need or don’t need to help you engage your students; and the type of instruction specific to developmental mathematics. What we discuss will be recorded and later transcribed. The transcripts of today’s interview will be available in the near future. If you would like to read them, please contact me. Do you have any questions before we start?

Types of Strategies to Promote Active Learning:

1. What were your plans for getting your students engaged in the learning process in today’s lesson?
2. How engaged do you think the students were in today’s class? Explain.
3. What types of instructional strategies did you use in today’s class to engage students in the learning process? (Ask the following questions about each instance.)
   Follow-Up: How did you choose the mathematics task you used?
   Follow-Up: What kinds of questions did you intend to ask?

Support Needed for Teaching Developmental Mathematics:

4. What support did you use to help you create today’s lesson? (e.g. curriculum, colleagues, other?)
5. What type of instructional support do you feel would be helpful for you in designing or using instructional strategies to engage students in the learning process in today’s topic?
6. What types of interaction do you have with colleagues when discussing the design and implementation of instructional strategies to engage students in the learning process?

Instructor’s Beliefs Concerning Instruction for Developmental Mathematics:

7. How would you describe the typical developmental mathematics student?
8. What type of academic expectations do you hold for developmental mathematics students?
9. How do your expectations affect the instructional choices you make when teaching developmental mathematics?
10. Describe how you teach developmental mathematics as compared to how you would teach a credit-bearing college-level course.
VITA

Vickie Lynn Spain was born on September 19, 1962 in Montgomery, Alabama, the daughter of Linda and Edward Niedens, and was later adopted by Ann Niedens. She received a BS in Mechanical Engineering from North Carolina State University in 1985 and worked in that field for 6 years. Throughout the next several years she stayed at home with her children before deciding to return to college.

In 2001, she attained a BA in Middle Level Education (Grades 5-9) from Columbia College, allowing her to teach mathematics and science. Over a period of five years, she taught at the middle school and junior high levels in Hallsville and Columbia. Throughout these years, she especially enjoyed attending professional development seminars and conferences. Learning new ways of presenting mathematics conceptually to students became a passion of hers that she wanted to share with other teachers. Hence, she began the Masters program in Mathematics Education at the University of Missouri, while also working at Columbia College where she tutored mathematics at the Ether L. Bruce Math Learning Center. While tutoring undergraduate students at Columbia College, she found she really enjoyed teaching students in developmental mathematics courses. Her Masters thesis project focused on the learning strategies and study habits used by developmental mathematics students. In order to work with both preservice mathematics teachers and developmental mathematics students, she chose to stay at the University of Missouri after achieving her Masters in Mathematics Education in August of 2011 and work towards her Doctorate in Mathematics Education, completing it in 2015. For now, she has accepted a Faculty Appointment at Westminster College in Fulton, Missouri.