UNDERPREPARED COLLEGE STUDENTS' APPROACHES TO LEARNING MATHEMATICS WHILE ENROLLED IN A STRATEGY-EMBEDDED DEVELOPMENTAL MATHEMATICS COURSE AND WHILE SUBSEQUENTLY ENROLLED IN A COLLEGE-LEVEL MATHEMATICS COURSE THAT DID NOT PURPOSEFULLY EMPHASIZE THE USE OF MATHEMATICS-SPECIFIC LEARNING STRATEGIES

DISSERTATION

Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy in the Graduate School of The Ohio State University

By

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* * * * *

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1998
This qualitative investigation examined underprepared college mathematics students' approaches to learning mathematics under two conditions. First, the investigation examined students' responses to a college developmental mathematics course in which mathematics-specific learning strategy instruction was purposefully embedded. Second, the investigation examined the approaches to learning mathematics employed by eight of the developmental mathematics students who had completed the strategy-embedded developmental mathematics course and were subsequently enrolled in a college-level mathematics course that did not include a learning-strategy component.

Both theoretical and practical lenses were used to frame the current investigation. Social constructivist theory was used to inform the pedagogical components of the investigation and to clearly define the role of the instructor. The practical base for the project was grounded in the work of Dr. Claire Ellen Weinstein and in the details of her Learning-to-Learn course. Data collection and analysis were guided by theories of self-regulated learning. These theories also provided a language for communicating the results.
The details of the strategy-embedded developmental mathematics course taught at the Ohio State University during the fall of 1997 are included in this work. Nineteen students were enrolled in this remedial mathematics course and received instruction on reading a mathematical text, learning from a lecture, and taking notes. Additionally, students investigated available resources, monitored their understanding, and analyzed their errors as part of the course. As a result of strategy instruction students: (a) reported feeling less teacher driven; (b) took responsibility for their own successes and failures; (c) attributed failures to actions rather than abilities; (d) became familiar with a variety of different types of resources; (e) made decisions about when and why to use these resources; (f) learned to reflect on the outcomes of their decisions; and (g) gained a sense of control over their mathematical experiences.

Eight of the students (primary participants) who completed the strategy-embedded developmental mathematics course were interviewed as they progressed through their first college-level mathematics course. Four additional students (secondary participants) who had not enrolled in the strategy-embedded course also participated in this phase of the investigation. Data collected during the second phase were organized and analyzed using the three cyclical phases of self-regulation—forethought, performance, and self-regulations. With respect to the forethought phase, the primary participants set goals and devised plans of actions for navigating the college-level course. They also maintained a high sense of self-efficacy for learning throughout the term. With respect to the
performance phase, the primary participants were found engaging in a variety of different learning strategies. Self-monitoring, a performance-related activity, was difficult for all the participants. The primary participants used the knowledge they acquired during the self-reflective phase of self-regulated learning to develop new goals and devise new courses of action. These students, unlike the secondary participants, continued to refine their approaches to studying and learning throughout the term as the cycles continued.

Overall, the students who had participated in the strategy-embedded developmental mathematics took responsibility for their own successes and failures, and took control of their own learning during the college-level course. In addition to these findings, data also indicated that both the primary and the secondary participants found it difficult to identify main ideas in the college-level mathematics course. Topics and examples were viewed in isolation. This may serve to explain why students found it difficult to focus their study efforts.
Dedicated To All My Students...
past, present, and future
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Thank you...

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Rachel—for our wonderful conversations

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# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>ii</td>
</tr>
<tr>
<td>Dedication</td>
<td>v</td>
</tr>
<tr>
<td>Acknowledgments</td>
<td>vi</td>
</tr>
<tr>
<td>Vita</td>
<td>vii</td>
</tr>
<tr>
<td>List of Figures</td>
<td>xix</td>
</tr>
<tr>
<td>Chapters:</td>
<td></td>
</tr>
<tr>
<td>1. Introduction</td>
<td>1</td>
</tr>
<tr>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td>Overview of the Investigation</td>
<td>2</td>
</tr>
<tr>
<td>Overview of this Chapter</td>
<td>2</td>
</tr>
<tr>
<td>The Problem</td>
<td>3</td>
</tr>
<tr>
<td>1. Literature Review</td>
<td>5</td>
</tr>
<tr>
<td>A Limited Research Base</td>
<td>5</td>
</tr>
<tr>
<td>The Purpose of the Review of Literature</td>
<td>6</td>
</tr>
<tr>
<td>A Summary of the Literature Review</td>
<td>6</td>
</tr>
<tr>
<td>Nontraditional Placement of this Review</td>
<td>7</td>
</tr>
<tr>
<td>Summary</td>
<td>8</td>
</tr>
<tr>
<td>2. A Review of Student-Centered Investigations</td>
<td>8</td>
</tr>
<tr>
<td>Problem Solving and Metacognition</td>
<td>9</td>
</tr>
<tr>
<td>Findings</td>
<td>10</td>
</tr>
<tr>
<td>Summary</td>
<td>11</td>
</tr>
<tr>
<td>3. Strategy Instruction</td>
<td>12</td>
</tr>
<tr>
<td>viii</td>
<td></td>
</tr>
</tbody>
</table>
Study Skills Course .............................................. 13
Strategy Instruction in Developmental Reading .............. 15
  Monitoring Academic Progress ............................... 15
  Learning from a Lecture ..................................... 16
Summary .................................................................... 17
Pilot Investigations .................................................. 18
  Perception versus Reality .................................... 18
  Effort and Achievement ...................................... 20
  Students’ Approaches to Studying Mathematics .......... 21
  Helping Students Help Themselves ......................... 22
The Current Investigation ......................................... 23
  Research Questions ............................................ 24
  Significance of the Study .................................... 24
Overview of Chapters ............................................. 25
  Theoretical Considerations ................................. 25
  Methodological Considerations ............................ 25
Results .................................................................... 26
  Remedial Mathematics Experiences ....................... 26
  Participants’ Self-Regulatory Practices .................... 27
Discussion ............................................................ 28
2. Theoretical Considerations ..................................... 30
  The Roles of Theory in Qualitative Inquiry ............... 30
  What is a Framework? ......................................... 31
  Explicit Frameworks ......................................... 32
  Three Types of Frameworks ................................. 33
    Theoretical Frameworks ................................... 33
    Practical Frameworks ..................................... 34
    Conceptual Frameworks ................................. 35
  Theoretical Lenses ............................................. 36
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning-to-Learn Course</td>
<td>59</td>
</tr>
<tr>
<td>Course Features and Students' Study Activities</td>
<td>61</td>
</tr>
<tr>
<td>The Current Investigation</td>
<td>64</td>
</tr>
<tr>
<td>Framing the Current Investigation</td>
<td>65</td>
</tr>
<tr>
<td>Conceptual Framework for Data Analysis and Interpretation</td>
<td>65</td>
</tr>
<tr>
<td>3. Research Methodology</td>
<td>67</td>
</tr>
<tr>
<td>Introduction</td>
<td>67</td>
</tr>
<tr>
<td>Participatory Action Research</td>
<td>68</td>
</tr>
<tr>
<td>A Foundation for the Current Investigation</td>
<td>69</td>
</tr>
<tr>
<td>Research Questions</td>
<td>70</td>
</tr>
<tr>
<td>Investigation Participants</td>
<td>71</td>
</tr>
<tr>
<td>The Researcher</td>
<td>71</td>
</tr>
<tr>
<td>The Students</td>
<td>73</td>
</tr>
<tr>
<td>Students Enrolled in Strategy-Embedded Course</td>
<td>73</td>
</tr>
<tr>
<td>Participation Beyond Strategy-Embedded Course</td>
<td>74</td>
</tr>
<tr>
<td>Additional Participants</td>
<td>75</td>
</tr>
<tr>
<td>Openness</td>
<td>76</td>
</tr>
<tr>
<td>Ethics</td>
<td>76</td>
</tr>
<tr>
<td>Reciprocity</td>
<td>77</td>
</tr>
<tr>
<td>Data Sources</td>
<td>78</td>
</tr>
<tr>
<td>Instruments</td>
<td>78</td>
</tr>
<tr>
<td>Learning and Study Strategies Inventory</td>
<td>78</td>
</tr>
<tr>
<td>Reliability</td>
<td>79</td>
</tr>
<tr>
<td>Utility</td>
<td>79</td>
</tr>
<tr>
<td>Pilot Data</td>
<td>80</td>
</tr>
<tr>
<td>Activities for Embedding Strategies</td>
<td>80</td>
</tr>
<tr>
<td>Interviews</td>
<td>81</td>
</tr>
<tr>
<td>During Strategy-Embedded Course</td>
<td>81</td>
</tr>
<tr>
<td>During the Quarters Following Strategy Instruction</td>
<td>82</td>
</tr>
</tbody>
</table>
Rolling Pilot .............................................. 82
Initial Interviews ..................................... 82
Pre-Examination Interviews ....................... 83
Post-Examination Interviews ....................... 84
Observations .............................................. 84
Documents................................................ 85
During the Strategy-Embedded Course ............ 85
During the Quarter Following Strategy Instruction 86
Data Management and Analysis .................... 86
On-Going Data Analysis .............................. 86
Coding and Categorizing ............................. 87
Data Presentation ...................................... 88
Validity Concerns ...................................... 88
Self-Report Data: A Word of Caution ............. 89
Triangulation ............................................. 89
Peer Debriefing ......................................... 90
Member Checking ....................................... 91
Prolonged Engagement ............................... 91

4. Strategy-Embedded Developmental Mathematics Course ............... 92
   Introduction ........................................... 92
   Recommendations .................................... 93
   Focus of this Chapter ................................ 94
      The Students ..................................... 95
      Course Basics .................................... 95
      The Instructor .................................... 97
   Design of this Chapter .............................. 98
Week 1 .................................................. 98
   Course Content for Week 1 ......................... 100
   Embedded Strategy Instruction Emphasized during Week 1 101
Preparing for a Mathematics Exam ........................................124
Exam-Writing Tactics Revealed ............................................124
Proposed Study Strategies ..................................................126
Reflecting on Exam Preparation Strategies ...........................126
Journal Writing Assignment ..............................................127
Student Responses .........................................................127
Examination Results and Analyses ......................................129
Results ........................................................................129
Exam Correction and Analysis Assignment .........................130
Student Responses .........................................................132
Researcher-Teacher Reflections ..........................................133

Week 4 ...........................................................................133
Course Content for Week 4 ................................................134
Embedded Strategy Instruction Emphasized during Week 4 ....134
Recording Study Session Goals .........................................135
Learning to Establish Useful Goals ....................................136
Researcher-Teacher Reflections ..........................................137

Week 5 ...........................................................................138
Course Content for Week 5 ................................................139
Embedded Strategy Instruction Emphasized during Week 5 ....139
Study Session Goals .........................................................140
Preparation for Exam 2 .....................................................140
Preparation Strategies ......................................................140
Poor Strategies ...............................................................141
Class Discussion .............................................................141
Researcher-Teacher Reflections ..........................................142

Week 6 ...........................................................................143
Embedded Strategy Instruction Emphasized during Week 6 ....143
Preparing for Exam 2 .......................................................144
Study Session Goals ........................................144
Instructional Phases ......................................145
Whole-Class Discussion ..................................145
Examination Results and Analyses ......................146
Results ......................................................146
Exam Correction and Analysis Assignment ..........149
Investigating Available Resources ....................149
Researcher-Teacher Reflections ......................150

Week 7 ................................................................152
Course Content for Week 7 ..............................152
Embedded Strategy Instruction Emphasized during Week 7 ......153
Investigating the Next Mathematics Course ..........154
Relationship Between Scores and Students’ Actions ......156
Researcher-Teacher Reflections ......................157

Week 8 ................................................................157
Embedded Strategy Instruction Emphasized during Week 8 ......158
Researcher-Teacher Reflections ......................159

Week 9 ................................................................160
Embedded Strategy Instruction Emphasized during Week 9 ......160
Researcher-Teacher Reflections ......................164

Week 10 ............................................................165
Embedded Strategy Instruction Emphasized during Week 10 ......165
Self-Evaluation Survey ......................................165
Statement 1 ......................................................168
Statement 2 ......................................................168
Statement 3 ......................................................168
Statement 4 ......................................................169
Statement 5 ......................................................169
Statement 6 ......................................................169

xv
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estelle</td>
<td>190</td>
</tr>
<tr>
<td>Secondary Participants</td>
<td>190</td>
</tr>
<tr>
<td>The College Algebra Course</td>
<td>192</td>
</tr>
<tr>
<td>Course Content</td>
<td>192</td>
</tr>
<tr>
<td>Course Evaluation</td>
<td>193</td>
</tr>
<tr>
<td>Winter 1998 Results</td>
<td>194</td>
</tr>
<tr>
<td>Student Participants’ Results</td>
<td>195</td>
</tr>
<tr>
<td>College Algebra Lectures</td>
<td>196</td>
</tr>
<tr>
<td>This Chapter</td>
<td>198</td>
</tr>
<tr>
<td>Cyclical Phases of Self-Regulation</td>
<td>198</td>
</tr>
<tr>
<td>Forethought Phase</td>
<td>200</td>
</tr>
<tr>
<td>Tad</td>
<td>201</td>
</tr>
<tr>
<td>Johnny</td>
<td>202</td>
</tr>
<tr>
<td>Jake</td>
<td>205</td>
</tr>
<tr>
<td>Donovan</td>
<td>207</td>
</tr>
<tr>
<td>Kelly</td>
<td>209</td>
</tr>
<tr>
<td>Mary</td>
<td>210</td>
</tr>
<tr>
<td>Rachel</td>
<td>210</td>
</tr>
<tr>
<td>Estelle</td>
<td>213</td>
</tr>
<tr>
<td>Secondary Participants</td>
<td>214</td>
</tr>
<tr>
<td>Summary</td>
<td>217</td>
</tr>
<tr>
<td>Performance Phase</td>
<td>219</td>
</tr>
<tr>
<td>Strategy Use</td>
<td>219</td>
</tr>
<tr>
<td>Plans and Actions</td>
<td>225</td>
</tr>
<tr>
<td>Monitoring</td>
<td>227</td>
</tr>
<tr>
<td>Attention Focusing</td>
<td>229</td>
</tr>
<tr>
<td>Secondary Participants</td>
<td>230</td>
</tr>
<tr>
<td>Summary</td>
<td>231</td>
</tr>
<tr>
<td>Self-Reflection Phase</td>
<td>233</td>
</tr>
</tbody>
</table>
Self-Evaluations ...................................................... 233
Attributions ......................................................... 236
Adaptivity ............................................................. 238
Summary ............................................................... 240
Summary ............................................................... 241
Emergent Themes .................................................... 243
Responsibility ......................................................... 243
Empowerment ......................................................... 243
The Big Picture ..................................................... 244

6. Discussion ........................................................ 246
Revisiting the Research Questions ................................. 246
Results of Mathematics-Specific Learning Strategy Instruction ..... 247
Participants’ Approaches to Learning in Subsequent Courses ...... 252
Summary ............................................................... 255
Research into Practice .............................................. 256
Future Research ...................................................... 258

Bibliography .......................................................... 259

Appendix A: Review of Literature ................................. 283
Appendix B: Mathematics-Specific Learning Strategy Resources .... 309
Appendix C: Interview Protocols .................................. 337
Appendix D: Additional Data on Original Investigation Participants ...... 342
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Summary of research findings on achievement college developmental mathematics</td>
<td>29</td>
</tr>
<tr>
<td>2.</td>
<td>The relationship between the three types of research frameworks</td>
<td>33</td>
</tr>
<tr>
<td>3.</td>
<td>Components of self-regulated learning theory</td>
<td>48</td>
</tr>
<tr>
<td>4.</td>
<td>Bi-dimensional analysis of metacognition</td>
<td>49</td>
</tr>
<tr>
<td>5.</td>
<td>Course features</td>
<td>62</td>
</tr>
<tr>
<td>6.</td>
<td>Breakdown of students enrolled in strategy-embedded developmental mathematics course</td>
<td>74</td>
</tr>
<tr>
<td>7.</td>
<td>Breakdown of students who continued to participate in the study including their scores on the comprehensive developmental mathematics final exam</td>
<td>75</td>
</tr>
<tr>
<td>8.</td>
<td>Triangulation in the current investigation</td>
<td>90</td>
</tr>
</tbody>
</table>
9. Breakdown of developmental mathematics students by classification ........ 95

10. Summary of learning strategy component of course for Week 1 ............ 101

11. Sample survey item .............................................................................. 108

12. Student survey responses ................................................................. 110

13. Summary of student scores on the 10 scales of the LASSI .................. 112

14. Summary of learning strategy component of course for Week 2 ........ 115

15. Summary of student choices ............................................................. 117

16. Template for taking notes during a mathematics lecture ................. 122

17. Summary of learning strategy component of course for Week 3 ........ 124

18. Descriptive statistics of Exam 1 grades ............................................ 130

19. Comparison of grades on Exam 1 ..................................................... 131

20. Summary of learning strategy component of course for Week 4 ....... 134

21. Summary of learning strategy component of course for Week 5 ....... 139

22. Summary of learning strategy component of course for Week 6 ....... 144

23. Descriptive statistics of Exam 2 grades ............................................. 147

xx
38. Comparison of final course grades ........................................179
39. Summary of student evaluation of instruction .........................180
40. Developmental mathematics course results ..........................186
41. Final course grades .........................................................191
42. Grade distributions for college algebra major exams ...............194
43. College algebra final exam and course grade distributions .........195
44. College algebra exam scores and final course grades for Winter 1998 ....196
45. Self-report data on study participants who were not enrolled in the strategy embedded developmental mathematics course ...............196
46. Strategies used by primary participants during college algebra ..........220
47. Learning strategies used by primary participants .....................225
48. Follow-up data on original investigation participants ...............345
CHAPTER 1

INTRODUCTION

"Traditionally, academicians thought of [intermediate algebra] courses as weeding-out courses, but with reemphasis on retention and equal access to education, postsecondary institutions are rethinking this attitude."
(Stratton, 1996, p. 29)

Introduction

With a change in attitude regarding developmental (remedial) mathematics at the postsecondary level comes a need for a change in action. According to Bass (1997), "Mathematical scientists typically address educational issues exclusively in terms of subject matter content and technical skills, with the 'solution' taking the form of new curriculum materials" (p. 20). This type of "solution" is reflective of the teaching-by-telling model of instruction typically employed by postsecondary mathematics instructors. Hidden in this solution is the belief that if subject matter content is clearly presented, then any student who wants to learn can learn.

The current investigation is an attempt to expand this solution to include the student as an active participant in his/her learning process. Using an action research
methodology, participants in the current investigation were enabled to productively analyze and direct their mathematics-specific learning efforts. In changing the focus from the *curriculum* to the *student*, we are changing the question from “What can we do to the student?” to “What can we do for the student?” in order to promote success.

**Overview of the Investigation**

This qualitative investigation examined underprepared college mathematics students’ approaches to learning mathematics under two conditions. First, the investigation examined students’ responses to a college developmental mathematics course in which mathematics-specific learning strategy instruction was purposefully embedded. Second, the investigation examined the approaches to learning mathematics employed by eight of the developmental mathematics students who had completed the strategy-embedded developmental mathematics course and were enrolled in a college-credit mathematics course that did not include a learning-strategy component.

**Overview of this Chapter**

In this chapter the reader will find a discussion of one of the biggest problems that college and university mathematics departments currently face—low student achievement at the developmental mathematics level (**The Problem**). After the problem is developed, a review of the research base on student achievement in
college developmental mathematics is discussed (Literature Review). Research investigations directed at improving achievement are also presented.

Because several components of the current investigation were informed by a series of pilot investigations conducted by the researcher, a chronology of these investigations is included herein (Pilot Investigations). The chapter concludes with the statement of the specific research questions that were used to guide this investigation and with an overview of the remaining chapters (The Current Investigation).

The Problem

Many students begin their postsecondary education with an inadequate foundation in basic mathematics. The American Mathematical Association of Two-Year Colleges (AMATYC) (1995) reported that, in 1990, 56% of all students studying in two-year college mathematics departments were enrolled in remedial-level courses. AMATYC also reported that approximately 15% of all mathematics students attending four-year colleges and universities were enrolled in pre-algebra mathematics. Nationwide figures suggest that 1.1 million college students are currently studying mathematics at the remedial level (AMATYC, 1995).

Student achievement in developmental mathematics is vital to any mathematics program (AMATYC, 1995). Upon satisfactory completion of some type of developmental mathematics sequence, students register for traditional
mathematics courses. Hence, successful remediation programs are necessary in order to sustain enrollment in college-level mathematics courses.

Low student achievement in developmental mathematics courses at the postsecondary level is a growing concern for college and university mathematics departments. Although the percentage of students placed in remediation has remained relatively stable over the past six years, college enrollment has increased. Increased enrollment at the developmental mathematics level, however, has not resulted in increased enrollment in college-level mathematics courses (Albers, Loftsgaarden, Rung, & Watkins, 1992). The problem is clear: Remediation efforts at the developmental mathematics level have failed to meet the needs of many of our postsecondary students.

The current investigation is an attempt to address this problem. This researcher is interested in improving student achievement in college developmental mathematics courses as well as promoting student success in college-level mathematics courses. In particular, this dissertation focuses on student-centered methods for impacting student achievement among mathematically underprepared populations.
Literature Review

A discussion of the research base on student achievement in college developmental mathematics is found herein. A subset of this literature is presented in detail. This subset focuses on research investigations aimed at improving student achievement by enabling students as learners.

A Limited Research Base

The research base on student achievement in developmental mathematics at the postsecondary level is not as expansive as one might expect. Several factors may contribute to this deficit. For instance, the vast majority of developmental mathematics courses are taught by community college faculty. Teaching, rather than research, is of primary interest in these institutions. Additionally, developmental courses are often assigned to part-time instructors or graduate students (Crossroads, 1995). University mathematics faculty rarely teach developmental courses (Crossroads, 1995), are typically not interested in instructional research (Bass, 1997), and have even been known to speak out against university-supported remedial programs (Mityagin, 1996).

Many of the teachers who are "down in the trenches," working diligently to improve the experiences of developmental mathematics students, have neither the time nor the inclination to publish formal reports detailing their efforts. A review of the research literature on student achievement in postsecondary developmental mathematics confirms this observation. This lack of research literature, however, in no way negates the importance of a thorough literature review.
The Purpose of the Review of Literature

A literature review has multiple purposes and is a vital component of any research investigation. The purposes of a literature review may include (but are not limited to):

- assisting the researcher in question generation;
- informing the methodological and theoretical components of the investigation;
- situating the study amid a larger body of research; and
- establishing credibility within the research community and/or the stakeholders in the field.

In the current investigation, the literature review was used to address each of these purposes. Additionally, the research findings were used to inform every phase of the investigation.

A Summary of the Literature Review

In an earlier attempt to narrow the focus of the current investigation—impacting student achievement—an extensive literature review was conducted (Smith, 1996a). This review, located in Appendix A, includes information about affective variables related to mathematics achievement (Abramson, Seligman, & Teasdale, 1978; Dwinell & Higbee, 1991; Fennema & Sherman, 1976; Ferguson, 1986; Sowa & Burks, 1983; Tobias, 1991; Trent & Fournet, 1987); student achievement predictors (Bridgeman, 1982; Educational Testing Service, 1979;
Ervin, Hogrebe, Dwinell, & Newman, 1984; Reilly, 1974); and instructional strategies/environments associated with achievement in lower-level college mathematics courses (Burmeister, Carter, Hockenberger, Kenney, McLaren, & Nice, 1994; Chang, 1985; Clark & Halpern, 1989; Dees, 1991; Freigenbaum & Friend, 1992; Gaynor & Millham, 1976; Glucksman, 1973; Kenney & Kallison, 1994; Martinez & Martinez, 1992; McMillon, 1994; Rohm, Sparzo, & Bennet, 1986; Stratton, 1996; Watson, 1996). This review also includes an overview of non mathematics-specific research articles that focus on increasing student success by teaching students to improve their learning strategies. (See Figure 1 at the end of this chapter.)

**A Case for the Nontraditional Placement of this Review**

The aforementioned literature review is not included in its entirety in the body of this dissertation for several reasons. First, the mathematics-specific portion of the review best supports the current investigation by demonstrating a void in the literature. The existing research base on student-centered approaches to promoting mathematical achievement—the focus of the current investigation—is quite limited. Most of the published research on achievement in lower-level college mathematics focuses on factors external to the learner (i.e. class size, examination frequency, curricular materials). In other words, the majority of the investigations found in the literature are responding to the question, “What can we do to the student?”

Second, the non mathematics-specific portion of the literature review was used to inform the methodological and theoretical components of the current
investigation. For this reason, these research findings have been incorporated throughout the dissertation where they are most relevant (Chapters 2, 3 and 4). Finally, the nontraditional placement of this review helps to support the readability and flow of this document.

**Summary**

Interested readers will find the complete literature review located in Appendix A. This review is evidence that I have “done my homework”—that I am familiar with the studies on student achievement in college developmental mathematics that have already been conducted. Taken collectively, these studies reveal a lack of research on student-centered approaches to promoting the achievement of underprepared mathematics students. Hence, a need for the current investigation is supported.

Some of the research studies found in this review, however, provide more direct support for the present investigation and have been incorporated throughout this document. A description of some of these investigations follows.

**A Review of Student-Centered Research Investigations**

In my search for student-centered investigations, I was drawn to studies that focused on developing self-regulated, strategic learners. According to Pintrich and Schunk (1996):

*Self-regulation* is the process whereby students activate and sustain cognitions, behaviors and affects that are systematically oriented toward attainment of their goals. Students motivated to attain a goal engage in self-regulated activities they believe will help them (i.e. rehearse material to be learned, clarify unclear information). In turn, self-regulation promotes
learning, and the perception of greater competence sustains motivation and self-regulation to attain new goals. (p. 182)

According to Pintrich (1995): "Teachers can teach in ways that help students become self-regulated learners" (p. 9). Pintrich offers several recommendations for promoting student self-regulation: (a) Students must become aware of their task-specific behaviors, motivations, and cognitions; (b) Faculty must adopt models of instruction that include self-regulated learning components; and (c) Students must practice self-regulated learning strategies.

The summaries that follow are descriptions of research investigations that focus on the development of academic self-regulation. The findings and recommendations reported herein were used to inform the current investigation. I begin with an overview of the research on problem solving and metacognition.

**Problem Solving and Metacognition**

In the domain of mathematics education, research on problem solving and metacognition is closely tied to self-regulation. Research in mathematics education on problem solving has tended to focus on four areas of inquiry: identifying difficult problem features (early 1970s until early 1980s); describing characteristics of expert and novice problem solvers (late 1970s until mid 1980s); teaching problem-solving skills and heuristics (early 1980s to early 1990s); and understanding the role of metacognition in mathematical problem solving (early 1990s to present) (Lester, 1994). Early problem-solving research focused almost exclusively on task variables (Schoenfeld, 1992). This research, however, failed to consider the characteristics of
the problem solver (i.e. traits, dispositions, background). Researchers eventually began to investigate the characteristics of good and bad problem solvers.

According to Lester (1994), research findings suggest that good problem solvers tend to focus their attention on structural features of a problem rather than surface features, are aware of their problem-solving strengths and weaknesses, and continually monitor their efforts during problem-solving activities (see Cai, 1994). Lester (1994), however, warned that, "trying to teach these ways to novices in a short amount of time may not result in desirable outcomes [because] problem-solving processes and heuristics develop slowly over time" (p. 665).

**Findings.** The research literature does provide some general information on problem-solving instruction (Schoenfeld, 1992; White & Kitchen, 1991). First, teaching students about problem solving will be ineffective if students are not required to practice the strategies by solving many problems. Second, students will value problem-solving instruction only if problem solving is valued by the instructor. Finally, problem-solving skills develop slowly over a prolonged period of time.

Recently, research on the role of metacognition in mathematical problem solving has generated several interesting findings (Lester, 1994, pp. 666-667):

1. Effective metacognitive activity during problem solving requires knowing not only what and when to monitor, but also how to monitor.
2. Teaching students to be more aware of their cognitions and better monitors of their problem-solving actions should take place in the context of learning specific mathematics concepts and techniques.

3. The development of healthy metacognitive skills is difficult and often requires unlearning inappropriate metacognitive behaviors developed through experience.

There is evidence that "unlearning" is quite challenging for adult learners (Smith, 1997). The older strategies are typically favored by these students because they are more readily accessible, require less effort, and are closely connected to domain-specific (mis)conceptions (Pressley, 1995).

**Summary.** Based on the aforementioned findings, one of the goals of mathematics instruction might be to help students learn *when, what, and how* to monitor their progress in the domain of mathematics. This type of strategy instruction, according to Lester (1994), should be context-specific. These recommendations, therefore, support the embedding of mathematics-specific learning strategy instruction within content courses—a key feature of the current investigation.

The following study describes one attempt to embed mathematics-specific learning strategies within a college developmental mathematics course. Although student achievement was not significantly influenced by strategy instruction, other positive results were indicated. Additionally, the researcher-teachers in the
following investigation conveyed a strong sense that this type of instruction was "a good thing."

**Strategy Instruction**

Hodge, Ouzts-Simpson, and Preston-Sabin (1993) used note-taking instruction, collaborative learning activities, and textbook reading strategies with their developmental mathematics classes in an attempt to "put the power of learning into the students' hands" (p. 13). Students were first taught to use a modified version of the Cornell Method of notetaking. Lecture notes intentionally modeled this format. Students were then instructed to transfer important information (i.e. formulas, sample problems) from their notes to notecards. Students were encouraged to shuffle the cards and practice the problems in random order.

Reading a mathematics book is often difficult for students. Hodge, Ouzts-Simpson, and Preston-Sabin (1993) taught their students to read mathematical texts by first skimming the material, then reading the entire section at a rapid rate, and finally, carefully rereading the section with pencil in hand (see also Johnson, 1984). The researchers found that students did read their texts when they were specifically instructed to do so.

As a result of the strategy instruction provided in these developmental mathematics classes, the researchers reported that their students "expressed strong feelings of being in control of their learning. They felt less 'teacher' driven, more personally motivated, and in charge of their mathematics education" (Hodge, Ouzts-Simpson, & Preston-Sabin, 1993, p. 21).
Study Skills Course

In my review of the literature I found one researcher-teacher (Waycaster, 1993) who created a study skills course specifically for college developmental mathematics students. A variety of mathematics-specific learning strategies were taught in this supplemental course. Unlike the previous investigation (Hodge et al., 1993), strategy instruction was not embedded within the content course.

The results of this study (Waycaster, 1993) are significant to the current investigation because the findings indicate that the link between the study skills course and the content course was essential to the promotion of student success. Hence, embedding strategy instruction within the content course—as is the case in the current investigation—would be one way of strengthening this connection.

Waycaster (1993) observed that regular study skills courses contained little or no information on how to adapt study techniques for courses like mathematics. In an attempt to fill this void, she created a new course, a Math Study Skills course. During the fall of 1991, 19 students enrolled in the new course. Six of the 19 students were simultaneously enrolled in a developmental mathematics course. The Math Study Skills course topics included:

- Why do we need a Math Study Skills course?;
- Attitudes toward mathematics classes;
- How to prepare for the first day of class;
- What to do during the class;
• How to study and learn mathematics;
• How to prepare for and take a mathematics test; and
• How to choose and use a calculator (Waycaster, 1993, p. 22).

In addition to the aforementioned topics, five mathematical content sessions were taught. These sessions focused on operations with fractions and word problems—two topics known to be difficult for developmental mathematics students.

Waycaster reported that of the six students, who were concurrently enrolled in a developmental mathematics course, three passed with a grade of C or better, and three withdrew—a 50% success rate. During the spring of 1992, thirteen of the students who had taken the Math Study Skills course enrolled in a mathematics course. Four students passed the course, one student failed, and eight withdrew—a 30% success rate. The researcher concluded that "study skills must be taught simultaneously with mathematics content for maximum learning to be achieved" (p. 21). The researcher went on to suggest that study skills training should be introduced to students as early as possible in their academic careers, and that study skills activities must be linked to graded projects or incorporated into tests.

Although the sample was small and the findings were perhaps modest, there is again strong practitioner (researcher) support for the teaching of mathematics-specific learning strategies. Waycaster (1993) obviously believes that this type of instruction will impact student achievement. If we, as researchers, are to narrow
the research-practice gap, then theories of practitioners—some of whom may be conducting research—must be articulated and valued (Robinson, 1998).

**Embedded Strategy Instruction in College Developmental Reading Courses**

The following investigations were conducted within college developmental reading courses. The learning strategies described within these investigations—monitoring academic progress and learning from a lecture—could easily be adapted for mathematics-specific instruction. In fact, these strategies may be two of the most useful strategies for developmental mathematics students because: (a) it is not uncommon for students to think they understand a mathematical concept when they are able to complete homework assignments based on models and examples, and (b) lectures are the most common form of college mathematics instruction.

**Monitoring academic progress.** Swanson (1985) recognized that "many college students fail to monitor and change their study learning procedures even when faced with failing grades on tests and other homework assignments" (p. 28). In an attempt to help students learn to monitor and regulate their own learning, the researcher used journal writing assignments and metacognitive strategy checklists with a group of 24 college developmental readers. Students were given journal writing prompts related to required textbook reading assignments. They were asked, for example, to describe specific behaviors they used when reading the chapter. Most of the students were not accustomed to journal writing and had to be encouraged to write for a sustained period of time (more than 5 minutes) in order to avoid superficial responses.
Immediately after finishing the journal questions, students were required to complete a metacognitive strategy checklist. Students were instructed to check only those items on the checklist that described their behaviors while reading. Items included: "Read study guide questions before I started reading the chapter" and "When I didn't understand what I was reading I reread it" (Swanson, 1985, p. 36). Students took objective quizzes (covering the content of the reading assignment) after completing the checklist. The researcher found that students who reported using the fewest strategies scored the lowest on objective quizzes. As the course progressed, the researcher also observed that students became more aware of the strategies that were effective as well as the strategies that were ineffective in the context of this particular course (see Zimmerman & Paulsen, 1995; MacGregor, 1993, for additional research on self-monitoring).

**Learning from a lecture.** In a study conducted by King (1992), underprepared college students viewed a lecture, took notes, and engaged in a variety of study strategies in preparation for an immediate exam. Students from three sections of a remedial reading and study skills course were assigned to one of three conditions. One section of students was trained to generate and answer questions based on a lecture. Students in another section were trained in summarization techniques, and a third section of students was designated the control group. The control group students simply reviewed their lecture notes in preparation for the exam.
The researchers found that both self-questioning and summarizing were effective strategies for learning from a lecture. Summarizers scored highest on the immediate exam, with self-questioners running a close second. One week after the lecture, a retention test was administered. The self-questioners outperformed the summarizers on this exam. Once again, the control group scored below both treatment groups.

Summary

This review of student-centered research investigations offers several recommendations for empowering students as learners. The current investigation was informed in multiple ways. For example, the researcher-practitioner reports reviewed herein each conveyed a strong sense that the researchers were “headed in the right direction.” They each reported positive—albeit modest—results.

Because domain-specific strategy instruction is a new area of inquiry—especially in the domain of college mathematics—these modest results do warrant further inquiry, thus supporting the current investigation. Additionally, these articles offer numerous suggestions on what strategies to teach, when to teach these strategies, and how to teach these strategies.

My thinking with respect to the current investigation was not only informed by the literature, it was also informed by my own personal experiences as a researcher-practitioner. The highlights of these experiences follow.
Pilot Investigations

For the past eight years I have been teaching college developmental mathematics courses (pre-algebra, basic algebra). Believing that all students are capable of learning mathematics, I originally assumed that those students who did not pass my courses were simply not putting forth the amount of effort necessary for their own success. Perhaps they were not doing their homework assignments, not studying for exams, or not asking for the help they needed. Simply put, I believed that effort (as measured by time spent studying) and achievement (course grades) in college developmental mathematics were positively correlated.

The words of my students, however, beckoned a reconsideration of my oversimplified theory. I often heard: "I don't understand why I can't pass the tests when I can do all of the homework assignments," or "The problems on the exams are nothing like the problems in the book," or "I understand everything when I do the homework, but I still can't pass an exam." How could this be? After all, exam items in developmental mathematics courses typically follow templates found in the course text.

Perception Versus Reality

In 1994, I was teaching two sections of college developmental mathematics at the University of Texas—Pan American. Immediately following the first major examination, I asked my students to recall and record the amount of time and effort they put into preparing for the exam. These reflections were collected and analyzed. The students were then asked to record their study efforts—as they
occurred—for the next three weeks (between Exam 1 and Exam 2). These logs were also collected and analyzed.

The recall data indicated that the majority of the developmental mathematics students had spent more time preparing for the first exam than the second exam. Student journal entries, however, told a different story. When students were asked to compare their study efforts for Exam 1 with their study efforts for Exam 2, most students said that they spent as much or more time preparing for the second exam. Their perceptions of time spent studying for Exam 1 were inaccurate.

A whole class discussion regarding this discrepancy was initiated. Students agreed that they often spent a great deal of time thinking and/or worrying about studying mathematics. Teresa, one of the developmental mathematics students, captured the sentiments of the class when she said: “Sometimes I know I have a math test coming, and all day long I think about needing to study. Then I go home and it feels like I’ve been doing math all day long, so I don’t really spend much more time studying” (Smith, 1994).

It appeared that students’ perceptions of time spent studying developmental mathematics were relatively inaccurate—and typically inflated—when this time was not purposefully self-monitored and recorded. Time spent thinking about studying mathematics and/or worrying about studying mathematics was perceived, by the students, as time spent studying and/or doing mathematics.
Effort and Achievement

Approximately two years ago I decided to informally interview a small group of self-professed “hard working” yet relatively unsuccessful mathematics students. Expecting to find that student self-reports of their study efforts were exaggerated—as was the case in the previous pilot investigation—I asked to see evidence of students’ efforts in the form of completed homework assignments, practice problems, and other traces of their study efforts. I also verified the amount of time these students spent in the university’s tutoring facilities. Much to my surprise, I discovered that many of these students were spending a substantial amount of time studying mathematics. They were completing most of their homework assignments, attending their mathematics classes on a regular basis, and doing additional work in preparation for exams.

At this point my focus had to change from how much the students were doing during their study sessions to exactly what they were doing during their study sessions. Perhaps their efforts were misdirected. Could it be that they simply did not know how to study mathematics? Student journal responses seemed to suggest that this might be the case. Consider the following.

When preparing for [mathematics] exams I seem to have a problem judging which ideas are most important. I know everything is important, but some things have more value than others—Manny, developmental mathematics student (Smith, 1997a).

I do not take very good notes and you can tell by the lack of what is in them. In the past I never needed to refer to my math notes. All I have ever really needed was an example or two—Julie, developmental mathematics student (Smith, 1997a).
When and where do students learn how to learn mathematics? What can instructors do to help direct students’ efforts? Is it possible to teach students how to monitor and regulate their learning with respect to mathematics? According to Rosenshine and Meister (1994), these questions need to be addressed in the research literature.

**A Qualitative Look at Students’ Approaches to Studying Mathematics**

In a subsequent pilot investigation conducted during the spring of 1996, 23 developmental mathematics students (one class) at the Ohio State University were asked about their approaches to studying mathematics. Data consisted of student journal entries, researcher field notes, and focus group interviews. The purpose of the investigation was to determine students’ natural (or preferred) approaches to studying mathematics. This information is vital to the current investigation because, as suggested by Lester (1994), unlearning inappropriate learning strategies may be quite difficult for students. These data revealed that:

- Students often studied “hard” problems when preparing for exams;
- Monitoring understanding was difficult for developmental mathematics students;
- Students were reluctant to change their approaches to studying even when their current strategies were ineffective;
- Mathematics instructors are often unaware of their students’ deficiencies with respect to studying; and
- Students need more practice using effective study strategies.
Based on the results of this investigation, I began looking for ways to help students improve their approaches to studying in the domain of mathematics.

**Helping Students Help Themselves**

During the summer of 1996, I developed materials—based on recommendations from the literature and practical observations—for the purpose of teaching and supporting the development of mathematics-specific learning strategies. Twenty-four developmental mathematics students at the Ohio State University enrolled in my strategy-embedded intermediate algebra course during the fall quarter of 1996. In addition to mathematical content, the course emphasized the use of mathematics-specific learning strategies. Materials intended to help students set goals, monitor academic progress, and implement plans of action were tested and refined.

Students received instruction on reading a mathematical text, asking good questions, and using available resources. Additionally, they learned about techniques for monitoring, self-evaluating, and self-assessing their academic progress. Notetaking strategies and time management skills were also modeled and discussed.

It was apparent from the beginning that students required detailed instructions regarding each strategy. Nothing could be assumed. For example, when first asked to compose a set of goals specific to the developmental mathematics course, many students responded as follows: “I want to ace this course” or “I plan to study hard and get good grades because of it.”
Their goals were distal, ill defined, and impossible to self-monitor and evaluate. As a result, this activity was modified to include instruction on goal setting.

Additional information regarding this pilot investigation can be found in the following chapters. These data were used to help shape and define the current investigation. The results of this initial pilot study on the teaching of mathematics-specific learning strategies were promising. Based on journal entries, interview responses, and course-related documents, I found that:

- Students gained a sense of control over their mathematics education;
- They took responsibility for their own learning—crediting themselves for their successes and failures rather than crediting external sources (i.e. teachers);
- Their study efforts became more directed and focused as the quarter progressed; and
- Effort and achievement were found to be positively correlated—even the students who were unsuccessful knew what they should have been doing and credited their lack of effort for their low achievement.

This brings us to the current investigation.

The Current Investigation

The inspiration for the current investigation came from the aforementioned research literature as well as from my own personal experiences and observations. At the heart of this inquiry is my desire to help underprepared mathematics students
successfully navigate their college-level mathematics courses—to enable students as learners.

**Research Questions**

The primary research questions that were used to guide the current investigation follow.

1. How do college students enrolled in a developmental mathematics course approach learning when mathematics-specific learning strategy instruction is embedded within the course? (See Chapter 4)

2. How do students who were enrolled in a strategy-embedded developmental mathematics course approach learning in their first college-credit mathematics course if strategy instruction is no longer a course component? (See Chapter 5)

Additional research questions included:

3. What strategies do students who have been introduced to mathematics-specific learning strategies chose to employ?

4. Why are these particular strategies selected?

5. What factors facilitate or impede the use of such strategies?

**Significance of the Study**

According to *Crossroads in Mathematics: Standards for Introductory College Mathematics Before Calculus* (1995), "students should emerge from developmental courses with the ability and confidence to go on to the study of higher levels of mathematics so that they may use mathematics effectively in their multiple roles as
students, workers, citizens, and consumers” (p. 24). The acquisition of mathematical content knowledge alone does not guarantee student success. In addition to mathematical ability, students must also be skilled as learners and they must believe they are capable of succeeding (positive self-efficacy beliefs). Hence, empowering students to monitor and direct their own learning by teaching mathematics-specific study strategies may enhance achievement and success as well as confidence.

**Overview of Chapters**

The following overview is offered in an attempt to help the reader navigate the remainder of this dissertation. Highlights and structural details are provided for Chapters 2 through 6.

**Theoretical Considerations**

The lenses that were used for collecting, interpreting, and analyzing the data in the current investigation are described in Chapter 2. The chapter begins with a discussion of the roles of theory in qualitative inquiry. This leads to a description of three types of research frameworks— theoretical, practical, and conceptual. Finally, a conceptual foundation for the current investigation is constructed. This foundation is grounded in theories of self-regulation and social constructivism.

**Methodological Considerations**

As with any investigation, the research questions and theoretical lenses shape the method of inquiry. A qualitative methodology was deemed most appropriate for
gathering data in the current investigation. Chapter 3 contains details about the various types of data that were collected and the multiple methods that were used for collecting these data. Specifically, this chapter—Research Methodology—addresses the who, what, where, when, how and why of the investigation:

- Who are the participants?
- What types of data were collected?
- Where and when were these data collected?
- How will these data be used to answer the research questions? and
- Why were these methods of inquiry selected?

Additional methodological considerations discussed in this chapter include data interpretation, data management, and data analysis techniques. Issues of validity are also addressed.

**Results**

The results of the current investigation are reported in Chapters 4 and 5. The first of these chapters contains a discussion of the strategy-embedded developmental mathematics course as well as students' responses to strategy instruction. The following chapter looks at the experiences of a subset of these developmental mathematics students as they enter their first college-level mathematics course.

**Remedial mathematics experiences of the participants.** In Chapter 4, the reader will find a week-by-week account of the classroom activities used in the
strategy-embedded developmental mathematics course. Samples of student work are presented as well as discussions of the trends and themes that arose throughout the course of inquiry. Additionally, researcher-teacher reflections are incorporated throughout this chapter.

Chapter 4 addresses the first research question: “How do college students enrolled in a developmental mathematics course approach learning when mathematics-specific learning strategy instruction is embedded within the course?”

**Self-regulatory practices in college-level mathematics courses.** Chapter 5 provides an in-depth look at the participants’ selective use mathematics-specific learning strategies in subsequent mathematics courses. This chapter addresses the remaining research questions regarding transfer of strategy use:

- How do students who were enrolled in a strategy-embedded developmental mathematics course approach learning in their first college-credit mathematics course if strategy instruction is no longer a course component?

- What strategies do students who have been introduced to mathematics-specific learning strategies chose to employ?

- Why are these particular strategies selected?

- What factors facilitate or impede the use of such strategies?
Discussion

This dissertation concludes with a discussion of the investigation processes and results (Chapter 6). The following considerations are addressed:

- How can these data be used to inform mathematics instruction?
- What recommendations might be gleaned from this investigation? and
- What avenues of inquiry need to be addressed in the future?
<table>
<thead>
<tr>
<th>FOCUS OF THE STUDY</th>
<th>RESEARCHERS</th>
<th>SUMMARY OF FINDINGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learned Helplessness</td>
<td>Sowa &amp; Burks (1983)</td>
<td>Teaching students to rephrase self-defeating statements can ameliorate learned helplessness and increase achievement.</td>
</tr>
<tr>
<td>Achievement Predictors</td>
<td>Bridgeman (1982)</td>
<td>Students who begin their college-level mathematics education at the remedial level are not necessarily low achievers in subsequent courses.</td>
</tr>
<tr>
<td>Class Size</td>
<td>Clark &amp; Halpern (1989)</td>
<td>Smaller class size may lead to increased achievement for underprepared students.</td>
</tr>
<tr>
<td>Mathematics Tutoring Labs</td>
<td>McMillon (1994)</td>
<td>Requiring students to attend mathematics lab sessions can increase achievement in developmental mathematics courses and in subsequent college-level courses.</td>
</tr>
<tr>
<td>Co-Courses</td>
<td>Petrig (1988)</td>
<td>Students always benefit from additional instruction.</td>
</tr>
<tr>
<td>Supplemental Instruction</td>
<td>Stratton (1996)</td>
<td>Students always benefit from additional instruction.</td>
</tr>
<tr>
<td>Reading a Math Text</td>
<td>Kenney (1989, 1990)</td>
<td>Reading a mathematics text is difficult for students; and they typically do not read the text unless they are told to do so. Students who learn to use their texts gain a sense of control of their learning.</td>
</tr>
<tr>
<td>Monitoring Progress</td>
<td>Hodge, et al. (1993)</td>
<td>Students must be taught when and how to monitor their mathematical progress. Instruction is most salient when it takes place in the context of learning specific mathematics concepts. Student awareness of strategy use leads to increased monitoring as well as subsequent modification of learning strategies.</td>
</tr>
<tr>
<td>Study Skills Courses</td>
<td>Schoenfeld (1992)</td>
<td>Studies taught in study skills courses are more likely to be applied during the students’ term of enrollment in the study skills course. Transfer may not occur unless the goal of transfer is explicit.</td>
</tr>
<tr>
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<td>Lester (1994)</td>
<td>Studies taught in study skills courses are more likely to be applied during the students’ term of enrollment in the study skills course. Transfer may not occur unless the goal of transfer is explicit.</td>
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<tr>
<td>Study Skills Courses</td>
<td>Waycaster (1993)</td>
<td>Studies taught in study skills courses are more likely to be applied during the students’ term of enrollment in the study skills course. Transfer may not occur unless the goal of transfer is explicit.</td>
</tr>
<tr>
<td>Study Skills Courses</td>
<td>Weinstein (1994)</td>
<td>Studies taught in study skills courses are more likely to be applied during the students’ term of enrollment in the study skills course. Transfer may not occur unless the goal of transfer is explicit.</td>
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Figure 1: Summary of research findings on achievement in college developmental mathematics
CHAPTER 2

THEORETICAL CONSIDERATIONS

"Qualitative researchers often make use of theories as a framework for both asking questions for their study and discussing aspects of their findings" (Glesne & Peshkin, 1992, p. 20).

The Roles of Theory in Qualitative Inquiry

Social scientists define the roles of theory in qualitative research in different ways. Some researchers use theory to frame and guide their investigations. Others challenge the authority of existing theories by introducing new complexities and contradictory data. Yet others view theory as a product, rather than a tool, of qualitative inquiry.

Traditionally, researchers have defined theory as a set of pre-existing propositions or interrelated constructs that function to explain and predict human behavior. Interpretivists, however, have a different view. They see the goal of theorizing as, "providing an understanding of direct 'lived experiences' instead of abstract generalizations...[Interpretivist researchers believe that] every human
situation is novel, emergent, and filled with multiple, often conflicting meanings and interpretations" (Glesne & Peshkin, 1992, p. 19). Findings from interpretivist inquiries often oppose existing theoretical models.

Grounded theorists (see Glaser & Strauss, 1967), on the other hand, conduct research for the purpose of theory development. Resulting theory is closely tied to the research site and design, and may serve as a foundation for new theory in the traditional sense.

The present qualitative investigation makes use of existing theory as one component of its structural frame. The details of this structure follow. This chapter begins with a discussion of the three types of frameworks most often selected to guide research investigations—namely, theoretical, practical, and conceptual frameworks. Conceptual frameworks are unique in that they respect both theoretical and practical knowledge. Because the current investigation was built on a conceptual frame, both theoretical and practical issues are discussed herein.

What is a Framework?

Frameworks are more than just obligatory components of research projects and dissertation investigations. The American Heritage Dictionary of the English Language (1980) defines a framework as “a structure for supporting, defining, or enclosing something; especially, skeletal erections and supports used as the basis in something being constructed.” Every research investigation has a framework—a structure. Some are implicit while others are explicit. There are
also several different types of frameworks. Some are theoretical, others are practical; and still others are conceptual (Eisenhart, 1991).

**Explicit Frameworks in Qualitative Inquiry**

An explicit framework is a vital component of any qualitative research investigation. Frameworks guide the process of data collection and bring focus to the study. Frameworks also provide the lenses for interpreting and analyzing the products of an investigation. According to Eisenhart (1991), “the originally specified research framework may or may not continue to serve as a guide for data analysis and explanation, but some framework—some coherent way of thinking about how to organize and interpret the data—must” (p. 204).

In addition to having an explicit framework to guide a research project, the investigator must share her/his framework with other members of his/her scholarly community. According to Romberg (1992),

Too often, researchers report only procedures and findings, not the model or worldview. The findings of any particular study are interpretable only in terms of the worldview. If it is not stated, readers will undoubtedly use their own notions to interpret the study. (p. 53)

The framework used in the current investigation for data collection—a conceptual framework relying heavily on practical knowledge—is presented at the end of this chapter. As suggested by Eisenhart (1991), a different conceptual framework was used to guide the analysis portion of this investigation.
Three Types of Frameworks

As previously mentioned, three types of frameworks have typically been adopted by qualitative researchers—theoretical, practical, and conceptual (Figure 2).

![Diagram of Types of Research Frameworks]

Figure 2: The relationship between the three types of research frameworks

Theoretical Frameworks

Frameworks that rely on well-established, formal bodies of knowledge (theory) are known as theoretical frameworks. Piaget’s theory of cognitive development in children and Vygotsky’s cultural-historical theory of learning are two examples of frames that have been used for research in mathematics.
education. If a theoretical framework is selected to guide a study, then the researcher typically follows the accepted methodological and analytical conventions associated with the theory (Eisenhart, 1991).

One of the drawbacks of relying solely on formal theories as lenses for conducting research is the potential for loss of important and/or interesting information (Becker, 1991). Data that does not fit the components of the selected theoretical model typically does not make it to the analysis phase of the investigation.

**Practical Frameworks**

A practical framework is a structure for guiding a research investigation that is based on practitioner knowledge and experience. Scriven (1986) highlights the differences between theory-driven research and what he calls the “practical research approach.” According to Scriven, when theorists are asked about ways to improve teaching in a particular setting, their solutions most often rely on the conduct of better investigations—deeper literature reviews, stronger designs, and more careful analysis.

A practical researcher, on the other hand, would approach the same task in a very different manner. She/he might begin by “identifying a number of practitioners who are outstandingly successful at the task in question...and identify the distinctive features of their approaches. [One] would then teach new or unsuccessful practitioners to use these winning ways and retest until an exportable formula is derived” (Scriven, 1986, p. 59).
According to Eisenhart (1991), one of the dangers of practical frameworks is that the conclusions of the research investigation may reflect nothing more than preexisting practitioner knowledge. Additionally, when the researcher is an “insider”—someone who regularly participates in the practice under investigation—there is a tendency to ignore or fail to recognize the “taken-for-granted” constraints of the study.

**Conceptual Frameworks**

Conceptual frameworks offer the best of both worlds—the world of theory and the world of practice. A conceptual framework is a “skeletal structure of justification rather than a skeletal structure of explanation” (Eisenhart, 1991, p. 209). This type of framework often relies on both formal theory and practitioner knowledge to build an argument for adopting particular ideas or concepts that will be used to guide the investigation. Theoretical constructs serve as lenses for data collection and often provide the language for discussing the results of the investigation. Practitioner knowledge may be used to explain why certain aspects of various theories are valued over others.

A conceptual framework accommodates both insiders’ (practitioners) and outsiders’ (theorists) perspectives (Eisenhart, 1991). One of the major differences between conceptual frameworks and purely theoretical frameworks is that researchers using conceptual frameworks often define concepts during and/or after the data collection process has occurred—not prior to entering the field. In
the current investigation, for example, both *studying* and *learning* were left nonoperationalized prior to the investigation (Denzin, 1978).

As previously stated, a conceptual framework was used to guide the current investigation. Because conceptual frameworks value both theoretical and practical knowledge, a discussion of both theory and practice is warranted herein.

**Theoretical Lenses**

If one were to ask a researcher in educational psychology how to study *studying*, self-regulated learning theory would undoubtedly be included in his/her response. Ask the same question of a researcher in mathematics education, and the word *constructivism* is almost guaranteed to come up. While self-regulated learning theory offers a cognitive explanation for learning, constructivism addresses the pedagogical aspects of the learning process.

These two theories offer complimentary rather than opposing explanations of learning. According to Palincsar (1998): “Virtually all cognitive science theories entail some form of constructivism to the extent that cognitive structures are typically viewed as individually constructed in the process of interpreting experiences in particular contexts” (p. 347).

Both constructivist theory—in particular, social constructivism—and self-regulated learning theory were used to guide the current investigation. A brief overview of each of these theoretical perspectives follows.
Social Constructivism

Social constructivist theory (Yackel & Cobb, 1996) follows the seminal work on symbolic interactionism (Bauersfeld, 1993) and adopts the metaphor of persons in conversation (Ernest, 1996). The interactionist position for mathematics education research is based on the assumption that "cultural and social processes are integral to mathematical activity" (Yackel & Cobb, 1996, p. 459). According to Bauersfeld (1993),

"Participating in the processes of a mathematics classroom is participating in a culture of using mathematics, or better, a culture of mathematizing as a practice. The many skills, which an observer can identify and will take as the main performance of the culture, form the procedural surface only. These are the bricks for the building, but the design for the house of mathematizing is processed on another level. As it is with cultures, the core of what is learned through participation is when to do what and how to do it."

(p. 4)

The mathematical edifice is an "inherently social construction, one that is a matter of communal sense-making, and [is] subject to revision in light of new data" (Schoenfeld, 1991, p. 265).

The symbolic interactionist approach is particularly useful when studying student learning in cooperative settings because it emphasizes individual sense-making as well as social processes (Yackel & Cobb, 1996). Individual mathematical knowledge is constructed when students participate in the negotiation of mathematical sense-making--when students do mathematics rather than reproduce the methods and procedures they have been taught (Schoenfeld, 1991).
According to Johnson and Johnson (1990), social constructivists base their theories on two fundamental principles: (1) active learning requires intellectual challenge and curiosity; and (2) challenge and curiosity are best aroused in discussions with other students.

Educational research offers compelling evidence that students learn mathematics well only when they construct their own mathematical understanding...This happens most readily when students work in groups [and] engage in discussion. (National Research Council, 1989, p. 59)

Social constructivists believe that students learn and experience higher levels of understanding when they are "stimulated by challenging activities in which they reason, conjecture, explain, resolve conflicts, and reflect on their learning processes" (Watson, 1995, p. 6).

The Connection Between Teaching and Learning

In asserting that knowledge is acquired through construction, theorists also concede that researchers' and teachers' knowledge of students' mathematics is also constructive (see Steffe, Nesher, Cobb, Goldin, & Greer, 1996). Teaching must therefore be regarded as an essential component of any model of mathematics learning (Hatano, 1996). According to Noddings (1990), the acknowledgment of cognitive constructivism necessitates the adoption of methodological constructivism. Pedagogical strategies must therefore stimulate and nourish students' own mental elaborations of mathematical knowledge in order to remain consonant with students' cognitive strategies (AMATYC, 1995; Noddings, 1990). An elaboration of the function of the teacher in a social constructivist classroom follows.
The Roles of Instructors

The instructor's role in the constructivist classroom is tri-fold. First the instructor must build a tentative avenue for the development of mathematical ideas (Confrey, 1990). For example, mathematical negotiations are often initiated as a result of a problem posed by the instructor (Koehler & Grouws, 1992). Tasks that encourage the students to take flexible approaches are necessary for the development of effective problem-solving behaviors (Good, Mulryan, & McCaslin, 1992).

A second role adopted by the instructor is that of facilitator. A facilitator encourages dialogue between students and "implicitly legitimiz[es] selected aspects of contributions to discussion in light of their potential fruitfulness for further mathematical constructions" (Koehler & Grouws, 1992, p. 119). As a facilitator the instructor uses questioning to refine student explanations. The instructor must listen to and continually analyze student conceptions and be willing to accept alternative interpretations that are supported by legitimate argument (Confrey, 1990; Yackel & Cobb, 1996). In addition, the instructor must highlight conflicts between alternative solutions in order to help students develop strategies for collaboration.

The instructor also serves as an active representative of the mathematical community. This role is often viewed as inconsistent with constructivist pedagogical practices (Yackel & Cobb, 1996). Cobb, Yackel and Wood (1992) clarify this misconception as follows,

The conclusion that teachers should not attempt to influence students' constructive efforts seems indefensible, given our contentions that mathematics can be viewed as a social practice or a community project.
From our perspective, the suggestion that students can be left to their own devices to construct the mathematical ways of knowing compatible with those of wider society is a contradiction in terms. (pp. 27-28)

It is the instructor's responsibility as the representative of the mathematical community to provide feedback on mathematical constructions that lack legitimacy and to redescribe students' explanations in more sophisticated terms (Koehler & Grouws, 1992).

**Summary**

The current investigation is problematizing learning and studying in the context of mathematics. The social constructivist perspective informed the learning strategy instruction component of this investigation. Active learning was emphasized. New information was scaffolded on existing knowledge; and activities that required students to explain, refine, and reflect upon their own learning were constructed.

While constructivist theory provides a pedagogical foundation for the current investigation, theories of self-regulation in academic settings offer support for the cognitive component. A discussion of self-regulated learning theory follows.

**Theoretical Roots of Self-Regulated Learning**

Most of the research on self-regulated learning in academic settings embraces a social-cognitive perspective. In order to provide a more complete analysis of self-regulation, we begin with an overview of Bandura’s (1986) social cognitive theory. This is followed by a review of theories from other areas of
cognitive psychology—areas seen as closely related to learner self-regulation. In particular, goal orientation and self-efficacy theories are discussed.

**Bandura’s Social Cognitive Theory**

Albert Bandura (1986) expanded traditional behavioral views of learning to include social influences. Social cognitive theory emphasizes that individuals learn by observing others (*vicarious learning*) as well as by doing and experiencing the consequences of their own actions (*enactive learning*). His theory also asserts that observable performance (behavior) and the acquisition of knowledge (learning) are distinct. In other words, individuals may possess knowledge that they are unwilling or unable to demonstrate—they may *know more than they show* (Woolfolk, 1998).

The learning process, according to Bandura (1986), is influenced by a variety of personal, behavioral, and environmental factors. Personal factors (self-efficacy judgments) include cognition, affect, and biological events. Behavioral factors (performance) include individual actions, choices, and verbalizations. Environmental factors include resources, instructional methodologies, and feedback from others. Bandura (1986) asserts that:

> In the social cognitive view people are neither driven by inner forces nor automatically shaped and controlled by external stimuli. Rather, human functioning is explained in terms of a model of triadic reciprocity in which behavior, cognitive and other personal factors, and environmental events all operate as interacting determinants of each other. (p. 18)

For example, interactions between behavioral and environmental factors occur when a teacher directs students’ attention during instruction (environment
impacting behavior) or when a student asks a question and the teacher responds (behavior impacting environment).

The behavioral-personal factor interaction is exemplified when students make judgements about their performance abilities (behavior impacting personal) and when these judgments—self-efficacy beliefs—influence choice, persistence, and effort (personal impacting behavior). Teacher beliefs and expectations (environmental factors) also impact students’ self-efficacy beliefs (personal factor).

As previously stated, social cognitive theory has been integrated with other areas of cognitive psychology resulting in theories of self-regulated learning. Before a discussion of self-regulated learning theory is presented, goal-orientation and self-efficacy theories are considered. These theories are closely connected to explanations of student learning and student achievement.

**Goal Orientation Theory**

According to Pintrich and Schunk (1996), goal orientation theory was developed to explain achievement behavior. The theory proposes that:

There are two general goal orientations that students can adopt toward their academic work: a learning goal orientation with the focus on learning and mastery of the content and a performance orientation with the focus on demonstrating ability, getting good grades or rewards or besting other students. (Pintrich & Schunk, 1996, pp. 252-253)

According to Maehr and Midgley (1991), a student with a learning goal orientation likes to learn, believes that understanding is more important than grades; and feels most successful when learning new things. With respect to a performance goal
orientation, Maehr, Midgley and their colleagues "have distinguished theoretically and empirically among three types of performance goal orientation: extrinsic, relative ability, and effort avoidance" (Pintrich & Schunk, 1996, p. 236).

**Performance goal orientation.** Students who are extrinsically focused do homework because it is graded or because of the consequences or rewards. Students who are relative ability focused want to be recognized by the instructor as smarter than other students and feel successful only if they perform better than other students. Students with an effort avoidance focus attempt to complete their work as quickly as possible without exerting too much effort.

**Learning goal orientation.** Students who display a high learning goal orientation use deeper processing strategies and engage in self-regulated learning behaviors (Pintrich & Schunk, 1996, p. 239). According to Ames (1992), "a mastery [learning] goal orientation is associated with a wide range of motivation-related variables that are conducive to positive achievement activity and that are necessary mediators of self-regulated learning" (p. 262).

**Task, authority, and evaluation.** Research indicates that students tend to adopt the goal orientations stressed in their classrooms (Ames, 1992; Ames & Archer, 1988; Maehr & Midgley, 1991). Ames (1992) has identified three classroom structures—task, authority, and evaluation—that contribute to a learning goal orientation. According to Ames (1992), tasks are embedded with information that "students use to make judgements about their ability, their
willingness to apply effortful strategies, and their feelings of satisfaction" (p. 263). Instructional strategies that foster a willingness in students to put forth effort have been identified (Ames, 1992). Educational tasks that foster a learning goal orientation are: (a) focused on understanding, (b) personally challenging, and (c) attainable.

In addition to task, student perception of control (authority) appears to be a significant factor affecting learning goal orientation. Research indicates that when external control is minimized students focus on the task at hand and, at the same time, conceptual understanding is facilitated (Ames, 1992). According to Ames (1992), supporting student autonomy in the classroom involves: (a) giving students real choices; (b) assigning responsibility for planning and completing tasks; and (c) developing students' self-management and self-regulatory strategies.

Students may be oriented toward different goals depending on how evaluation is structured. For example, evaluation that focuses on self-improvement, rather than social comparison, supports a learning goal orientation. When individual progress is emphasized, evaluation can be used to recognize students' efforts and encourage a view of mistakes as part of the learning process.
Self-Efficacy Theory

According to Bandura (1986), *self-efficacy* is defined as “people’s judgements about their abilities to organize and execute courses of action required to attain designated types of performances” (p. 391).

A sense of efficacy has four main influences: mastery experiences (past successes or failures in a particular area), vicarious experiences (observing others who are like us succeed or fail), social persuasion (encouragement from others), and physiological or emotional feedback (sweaty palms or relaxed responses taken as signs of the ability to do the task). (Woolfolk, 1998, p. 393)

Research suggests that students with a high sense of self-efficacy in a specific domain tend to persist longer in the face of difficulty, are not crippled by fear of failure, and are motivated to set higher goals (see Pajares, in press, for a complete review).

There is, however, evidence that “most students are overconfident about their academic capabilities” (Pajares, in press). Although self-efficacy beliefs that slightly exceed students’ accomplishments have been shown to increase effort and achievement (Bandura, 1996), little is known about the effects of efficacy beliefs that *greatly* exceed students’ accomplishments. For this reason, interventions that focus on improving students’ self-efficacy beliefs without addressing the self-regulatory components of learning may do more harm than good.
Summary

The overviews of social cognitive theory, goal orientation theory, and self-efficacy theory were intended to provide foundational support for the following discussion of self-regulated learning theory. In the next section, self-regulated learning is defined; the components of self-regulation are discussed; and research on self-regulation in academic settings is presented.

Self-Regulated Learning Theories


What is Self-Regulation?

According to Zimmerman (1998), “academic self-regulation is not a mental ability, such as intelligence, or an academic skill, such as reading proficiency; rather, it is the self-directive process through which learners transform their mental abilities into academic skills” (pp. 1-2). Self-regulated learners, “set goals for extending knowledge and sustaining motivation. They are aware of what they know, what they believe, and what the differences between these kinds of information imply for approaching tasks” (Winne, 1995, p. 173). Additionally, self-regulated learners:

- Evaluate learning situations in order to select domain-specific tactics;
- Monitor their progress toward goals, modifying plans as needed; and
- Continually revise and refine strategic plans for studying based on their prior successes and failures.

According to Winne (1995), self-regulation is theoretically and empirically linked to effective learning.

**Components of Self-Regulated Learning**

Theories of self-regulated learning "seek to explain students' personal initiative in acquiring knowledge and skill" (Zimmerman, 1990a, p. 10). In other words, they attempt to explain how students become masters of their own learning. According to Zimmerman (1990a):

Self-regulated learning theories of academic achievement are distinctive from other accounts of learning and instruction by their emphasis (a) on how students select, organize, or create advantageous learning environments for themselves and (b) on how they plan and control the form and amount of their instruction. (pp. 13-14)

Theories of self-regulated learning in academic settings typically consist of three interrelated components (Figure 3): strategy use, metacognitive awareness, and motivational control (Bruning, Schraw, & Ronning, 1995). A description of each of these components follows.

**Strategy use.** Self-regulated learning strategies are the "actions and processes directed at acquisition of information or skills that involve agency, purpose, and instrumentality perceptions by learners" (Zimmerman, 1990a, p. 5). Strategies that are employed when a student attempts to complete a homework
assignment in mathematics, for example, may include: (a) reviewing related notes from lecture; (b) reading and monitoring understanding in the text; (c) checking homework solutions with answers found in the back of the text; (d) generating questions to clarify understanding; and (e) seeking assistance from others (classmates, instructors).

Not all strategies are good strategies all the time. For example, if a mathematics student looks at the answer to a homework problem before attempting to solve the problem, then the student may work toward the correct solution without careful thought as to what he/she is doing—"I did it this way because it gave me the correct answer." On the other hand, a student who checks her/his completed assignment with the solutions found in the back of the text receives immediate feedback regarding the accuracy of his/her knowledge and
understanding of the assignment. This feedback may cue the student to continue with her/his current learning strategies—"I'm on the right track"—or to reconsider his/her approach—"There's obviously something I don't understand here."

Good strategy use involves more than knowing what to do. It also involves knowing how, why, and when to do it. For this reason, metacognitive awareness is recognized as one of the key components of self-regulated learning theory.

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<th>METACOGNITION</th>
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<td>KNOWLEDGE OF COGNITIONS</td>
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Figure 4: Bi-dimensional analysis of metacognition

**Metacognitive awareness.** According to Brown (1987), metacognition is bi-dimensional—it includes both knowledge of cognitions and regulation of cognition (Figure 4). The *knowledge of cognitions* dimension of metacognition includes knowledge about ourselves as learner and the factors that influence our
performance (declarative knowledge); knowledge about learning strategies (procedural knowledge); and knowledge about when and why to use a strategy (conditional knowledge) (Bruning, Schraw, & Ronning, 1995).

The *regulation of cognition* dimension of metacognition includes planning, regulation, and evaluation. Selecting appropriate learning strategies and allocating available resources are included in the *planning* component. *Regulation* activities include: making predictions, selecting appropriate repair strategies, and strategy sequencing. *Evaluation* refers to one's self-appraisals of products and regulatory processes.

Research suggests that "metacognitive awareness compensates for low ability and insufficient knowledge" (Bruning, Schraw, & Ronning, 1995, p. 102). Hence, underprepared students—developmental mathematics students, for example—may benefit from instruction that focuses on modeling and helping students develop metacognitive skills.

Knowing *what* to do as well as *how*, *why*, and *when* to do it is still not enough. In addition, self-regulated learners *want* to learn and *believe* that they can learn. These considerations are also included in the model. The *motivational control* component of self-regulation addresses a student's ability to set goals, evoke positive self-beliefs, and emotionally balance the demands of the learning process.

**Motivational control.** According to McMillan and Forsyth (1991), theories of motivation are concerned with three fundamental questions: "What
originates or initiates students’ arousal or activity? What causes a student to move toward a goal? and, What causes a student to persist in striving toward a goal?” (p. 40). Their heuristic model of motivation to learn (see McMillan & Forsyth, 1991) posits that both needs and expectations impact motivation. Self-worth, competence, and goals are viewed as determinants of needs. Self-efficacy, previous experiences, and attributions of success and failure are regarded as determinants of expectations.

Students displaying motivational control set realistic goals, regulate their anxieties and frustrations, and recognize the sources of their own strengths and weaknesses. They do not allow themselves to engage in self-defeating thought—“I don’t know why I even bother doing this homework, I’ll still fail the test.” They make accurate performance-related judgments—“I’m not surprised that I got a ‘D’ on the exam since I didn’t go to class at all last week.” And, they understand themselves as learners—“I know that if I wait until the last minute to study then I’ll get completely stressed out.”

**Summary.** Self-regulated learning involves strategy use, metacognitive awareness, and motivation control. Taken together, these inseparable components offer an explanation of learning in academic settings. According to theories of self-regulated learning, effective learners are aware of a variety of learning strategies. They know how to choose appropriate strategies and when to modify their approaches. They are able to control their frustrations and anxieties as well as any self-defeating behaviors that may impede learning.
The obvious questions arise: Can instructors help students to develop self-regulatory skills? Can motivational control, for example, be improved through instruction? Is metacognition a teachable component of self-regulation? Research suggests that learner self-regulation can be improved through instruction.

**Teaching Self-Regulated Learning Strategies**

Theoretically-based recommendations for teaching learning strategies to students are emerging in the literature (Zimmerman, 1990a). Four key recommendations can be found (Winne, 1995). First, learners must be taught *when*, and *why* to apply particular learning strategies (conditional knowledge). Next, learners must be taught *how* to apply this knowledge. The use of strategies may require cognitive, metacognitive, and behavioral skills. Third, students must be motivated to engage in the appropriate activities. Finally, learners must possess the domain-specific knowledge necessary for engaging in study.

**Research on Self-Regulation in Academic Settings**

Research on self-regulated learning in academic settings is quite diverse. Some investigations seek to describe students’ self-regulatory processes, while others focus on improving learner self-regulation. Within these two categories of research there are again distinctions. Some studies focus on strategy use, some on metacognition, and still others on motivation.

Because one of the theoretical lenses for the current investigation is self-regulated learning theory, understanding how other researchers conducted their
studies using this lens helped to inform the current investigation. Three examples of studies conducted under the umbrella of self-regulation are described below.

**Characteristics of the self-regulated learner.** Winne (1995a), in an attempt to understand how learners develop and use self-regulated learning (SRL) when they study alone, designed a qualitative observational study. This investigation was motivated by the researcher's assumption that "learning effectively by oneself will [continue to] remain a goal of education" (p. 173). The subject of Winne's study was Pat, a 4th-year honors psychology student enrolled in an advanced seminar on formal mathematical models. Winne describes Pat as a "cognitively well-prepared and self-regulated learner who thirsts for knowledge" (p. 174). Pat was observed by the researcher as she attempted to read, study, and understand a particularly challenging topic in preparation for an upcoming presentation.

Winne (1995a) found that Pat's approach to studying displayed three salient features. First, Pat was aware of factors that may impede learning, such as loss of focus or diminished attention. Second, Pat consistently selected goal-directed study tactics. For example, when faced with a difficult textbook problem, Pat first attempted to understand the question by defining each term; she then developed a concept map to represent the problem; and finally, she annotated each concept. According to Winne, the third feature of Pat's approach to studying can be characterized as affective and cognitive control. Although Pat was nervous about
her presentation, she used her emotions to motivate adequate preparation rather than to impede progress.

Diagnosing strategy use. Stockley, Winne, Hadwin, & Nesbit (1997) investigated students' capabilities to diagnose learning difficulties in peers. A group of 106 educational psychology students (undergraduates) interviewed peers, examined their written coursework, and generated recommendations (written reports) for improving their "client's" studying strategies (Stockley et al., 1997). Data consisted of interview records and written reports. Using a qualitative methodology, data were analyzed thematically. The researchers found that students most often emphasized the obvious in their recommendations: time management, effective note-taking strategies, and elaboration tactics. Stockley et al. (1997) concluded that "students' diagnostic capabilities are marginal to weak" (p. 7).

Notetaking instruction. O'Neill and Hynes (1985) investigated the relationship between notetaking ability and achievement with a group of college developmental reading students. Students were given a textbook selection to read and told to make notes on the material. After a designated period of time, the textbooks were surrendered, and the students were required to answer test questions using only their notes. Both literal and inferential questions were posed. According to the researchers, "the purpose of the test was not only to ascertain the manner in which students took notes but also to observe how well they were able to use this information to answer various types of questions" (O'Neill & Hynes, 1985, p. 83).
An analysis of 93 randomly-selected test papers and corresponding students' notes revealed that most students did recognize and use the major organizational patterns established by the author of the text. Students had difficulty, however, "sustaining a logical system of subordination between main ideas" (O’Neill & Hynes, 1985, p. 91). Many students had incomplete notes because they tended to write word for word instead of summarizing the information, and they simply failed to complete the notetaking portion of the assignment in the time allotted.

Students were most successful on the exam when the wording of the test question was the same as or similar to the wording of the text. Students were less successful when they were required to answer inferential questions. The researchers concluded that students have a minimal understanding of notetaking, are limited in their ability to utilize their own notes, and find it difficult to answer inferential questions based on their notes (see Pollio, 1990, for a review of notetaking research; Woolfolk, 1998, for interview study with successful notetakers by Pressley).

**Summary**

Recall that the current investigation was structured on a conceptual framework. Social constructivist theory and self-regulated learning theory were selected as the theoretical components of this frame. A significant portion of this chapter was devoted to a discussion of the theoretical origins and components of self-regulation. A sampling of research that was conducted using self-regulated learning theory as a lens was also included herein. These examples were used to
illustrate how other researchers have structured their investigations and reported their results within this framework.

Before continuing with a description of the practical lenses that informed the current investigation, a further discussion of theory is warranted. It seems that research investigations are also impacted by informal theories. Often these theories are implicit personal lenses that remain undiscovered and undisclosed. These implicit views, however, undoubtedly shape our methods of inquiry as well as our interpretations of the research events.

**Implicit Personal Theories as Lenses**

*Implicit theories* are “our individual submerged rationales about events in the world and about our own behavior in the world” (Rando & Menges, 1991, p. 7). These theories inevitably influence both classrooms and research investigations. They are an integral part of the lenses we use for interpreting classroom events, formal theories, and research results.

**Types of Implicit Theories**

Implicit theories have been viewed in the research literature as scripts (Roloff & Berger, 1982), syllogisms (Argyris, 1985), and broad orientations to teaching (Fox, 1983). Scripts are like little plays that are acted out in response to some cue. Mathematics instructors, for example, probably all have *scripted* responses to this question (often asked by algebra students during a lecture): “Isn’t there an *easier* way to do this problem?” Instructors’ responses to this query would reveal portions of their personal implicit theories with respect to
teaching and learning (the belief students are not interesting in learning, for example).

Logical syllogisms (if...then propositions) also reveal our implicit theoretical orientations. For example, consider completing the following statement:

*If half of my students failed the algebra exam, then*...

In your response, did you question the clarity of your instruction? This might indicate a belief that mathematical learning is facilitated by good, clear examples. Or, perhaps you questioned your instructional style. This might indicate a more constructivist orientation toward teaching and learning.

Finally, our implicit theories—our broad orientations to teaching and learning—are often revealed in our metaphorical language. For example, an instructor might suggest that *learning mathematics is like training for an athletic event—you can’t just watch, you have to do.* The use of metaphorical language for revealing implicit beliefs is quite common. Teacher educators often encourage students to develop their own metaphors for teaching and learning as a method of revealing and explicating their implicit theories (For examples see Wookfolk, 1998, and Weinstein, 1987).

**Making Explicit What is Implicit**

Throughout the current investigation, every effort has been made to make my implicit theories known. The use of descriptive detail in the reporting of data serves this end. Additionally, I have included an overview of my own personal
theory of teaching and learning specific to college developmental mathematics. This overview follows.

The metaphor that I have selected to describe learning in college developmental mathematics is *learning as information management*. This metaphor was selected for several reasons. Specifically, the mathematical content of a typical developmental mathematics course (e.g., operations with fractions and integers, solving linear and quadratic equations, graphing lines) is familiar to most students. Students have been taught (and retaught) many of these concepts for years. They recognize specific types of problems ("I've seen that before") as well as procedures for solving these problems ("Now that you have shown me an example, I remember that I already know how to do this"). But these two pieces of information are disconnected. In other words, students have difficulty knowing where to begin their problem-solving efforts.

Consistent with this view of learning, teaching might be likened to coordinating an on-the-job management-training program. Instruction could offer guidance that would allow students to develop as managers of their own learning and understanding. Students would be taught to seek connections between topics (to manage content). The instructor would model learning and monitoring strategies (training). And finally, students would gradually assume the responsibilities associated with managing their own learning.
In explicating my personal theories with respect to teaching and learning, I have provided the reader with insight into my own interests and decision-making processes with respect to the current investigation.

**Practical Lenses**

Practical lenses are another important component of the conceptual framework used to support the current investigation. The development of student self-regulation is still in its infancy and purely theoretical frameworks are not yet in existence. To date, very few models or guidelines have been developed to help students improve their self-regulation (Weinstein, 1996a).

**Learning-to-Learn Course**

In an attempt to address this void, Claire Ellen Weinstein and her colleagues at the University of Texas-Austin have developed a Model of Strategic Learning (Weinstein, 1987, 1994, 1996a, 1996b). This model emphasizes interactions among self-regulation, motivation (will), and learning strategies (skill) (Weinstein, 1996a).

Central to the model is the individual learner. According to Weinstein (1994), strategic learners possess a variety of different types of knowledge including: "(a) knowledge about themselves as learners (e.g., learning strengths / weaknesses, preferences, goals); (b) knowledge about different types of academic tasks (e.g., reading for understanding, taking notes, listening to a lecture, taking tests); (c) knowledge about strategies and tactics for acquiring, integrating, and applying, and thinking about new learning; (d) prior content knowledge; and (e)
knowledge of both present and future contexts in which the knowledge could be useful" (p. 258). Expert learners are those individuals who, among other things, know how to use these five aspects of relevant knowledge to monitor their own progress and meet their individual learning goals.

Learner expertise, however, requires more than proficiency in the five different types of knowledge. "Strategic learners also have metacognitive awareness and control strategies they can use to orchestrate and manage their studying and learning" (Weinstein, 1994, p. 259). This involves the use of self-regulatory activities. Learning activities designed to enhance self-regulation dramatically impact all other components of the model. The activities included in the self-regulation component of the model are: time management, comprehension monitoring, stress management, and systematic approaches to learning and accomplishing academic tasks (e.g., setting goals, reflecting, monitoring, evaluating progress, and modifying actions).

The Model of Strategic Learning also includes a variety of components external to the learner. Expert learners are aware of these factors (e.g., teacher expectations, nature of the learning activity, social context, available resources) and use this information to increase achievement outcomes.

Students enrolled in Dr. Weinstein’s study strategies course engage in a variety of activities designed to address the various components of the model. The first part of the course is devoted to an introduction of the Model of Strategic Learning. Students then learn to generate management plans for common academic
tasks (i.e. notetaking, learning from a lecture, preparing for and taking an exam); to set challenging, yet realistic academic goals; and to assess and revise their management plans and goals as needed. Each topic is related back to the Model of Strategic Learning in order to provide students with a schema for making sense of new information.

During the second half of the course, additional topics are introduced. These topics include (but are not limited to): knowledge-acquisition strategies, time management, reading strategies, attention and concentration, and dealing with procrastination. Finally, students learn how to adapt these strategies and skills to a variety of content courses.

Weinstein and her colleagues have found that participation in the Learning-to-Learn course is associated with improved grade point averages (both during and after course enrollment), higher retention rates for at-risk populations, and increased graduation rates. The details of this course informed the conceptual framework of the current investigation.

In addition to this practical support for helping students develop self-regulatory strategies, the current investigation was informed by another study. The following report addresses additional issues particularly relevant to college developmental mathematics student.

**Course Features and Students' Study Activities**

Recently, researchers have begun to investigate the differences between secondary and postsecondary course features (Matt, Pechersky, & Cervantes, 1991)
in an attempt to account for study deficiencies at the college level. Thomas, Bol, and Warkentin (1991) contend that,

Although basic skills and language deficiencies account for some of the difficulties students have at the postsecondary level, the primary problem seems to be that many students arrive at postsecondary institutions lacking the skills and dispositions necessary for engaging in sustained autonomous study...Given the widespread nature of students' study skill deficiencies at the postsecondary level, the apparent relationship between study activities and achievement at this level, and the size of the investment being made in remediating students' deficiencies, it is surprising how little is known about the antecedents of the problem. (p. 275-276)

In their survey investigation, Thomas et al. (1991) attempted to obtain a comprehensive picture of students' study activities (effort management, test preparation practices, information processing activities) in light of course requirements and other instructional provisions. The participants, ranging in grade level from junior high school to college, were all enrolled in social studies courses at the time of the survey. Course feature data were also collected.

\[ 	ext{Demands} \]

\[ \text{Supports} \]

\[ \text{Compensations} \]

Figure 5: Course Features
The primary goal of this investigation was to construct a theory of studying in academic settings. A framework for analyzing the survey data was developed and included a threefold distinction among course features: demands, supports, and compensations (Figure 5). The researchers observed that different courses impose different demands (standards, tasks, criterion performance events) on students' study activities. For example, increasing the amount of homework required for a course is a way of increasing the demands on students' study activities.

Supports are teacher-provided or textual aids that prompt students' engagement in study activities. Aids can take on the form of training, rewards, psychological support, or information. Compensations, on the other hand, are course features that act to reduce the effect of demands. The differences between supports and compensations are best illustrated by the following example:

Whereas college instructors might use the last class before a test to answer students' questions (a support), secondary-level teachers typically distributed handouts and conducted review sessions during this class period. In these review sessions, some teachers were observed to review questions, or questions and answers, which subsequently appeared verbatim fashion on the test [compensation]. (Thomas et al., 1991, p. 278)

A summary of their research findings follows.

With respect to course demand differences, Thomas et al. (1991) found that course work at the college level was not notably more difficult than at the high school level. Course load, however, increased significantly from high school to college. Additionally, at the high school level, teachers regularly supplemented text-based readings with teacher-developed summaries and handouts. These supports
were believed to decrease the need for student attention and student effort. At the college level, students were responsible for summarizing their own passages from texts.

Differences in test formats were also found. At the high school level, typically 80% of test items were designed to test low-level knowledge (terms, facts, principles). College-level exams required more integration of ideas and greater synthesis of information. These differences, coupled with the obvious ones (lax attendance requirements and the infrequency of exams in college, for example), may explain why many students are ill-prepared for college-level study.

Helping college developmental mathematics students understand the differences between high school and college-level mathematics courses is an important part of instruction in the current investigation. This knowledge may help to motivate students to consider different strategies for approaching learning in college.

**The Current Investigation**

Both theory and practical knowledge were used to inform the current investigation. Self-regulated learning theory not only provided the theoretical support for this study, but it also provided a language for communicating the results. Social constructivist theory was used to inform the pedagogical components of the current investigation and to clearly define the role of the instructor. The practical base for the current investigation was grounded in the
work of Claire Ellen Weinstein and in the details of her Learning-to-Learn
course.

**Framing the Current Investigation**

Each phase of the current investigation was conceptually framed. Some
aspects of this study were heavily influenced by practical knowledge, while others
were more theoretically oriented. The design of the strategy-embedded
developmental mathematics course, for example, relied heavily on practical
knowledge gained from Dr. Weinstein's work on the teaching of learning
strategies to underprepared college students.

The data collection phase of the current investigation was supported by both
theoretical and practical structures. Data that related to each of the three major
components of self-regulated learning theory as well as data that supported
Weinstein's Model of Strategic Learning were collected. The data analysis portion
of the current investigation was facilitated by Zimmerman's (1998)
conceptualization of the self-regulated learning process.

**A Conceptual Framework for Data Analysis and Interpretation**

Zimmerman (1998) identified three major cyclical phases that self-
regulated learning theorists have analyzed with respect to the learning process.
These phases are forethought, performance, and self-reflection. The forethought
phase includes goal setting, strategic planning, self-efficacy beliefs, and goal
orientation. Forethought processes prepare the learner for the performance
phase. Performance subprocesses include attention focusing, self-instruction,

These phases are cyclical in that self-reflection influences forethought and the cycle begins again. Data in the current investigation were analyzed in terms of these three cyclical phases—forethought, performance, and self-reflection.
CHAPTER 3

RESEARCH METHODOLOGY

"Classroom research should be held to a standard of usefulness and value to educational practitioners"
(Eisenhart & Borko, 1993, p. 75).

Introduction

I agree with Eisenhart and Borko (1993) that classroom research should address the needs of practitioners. This, however, is not enough. We, as researchers can address pertinent classroom issues and yet still have little or no impact on practice (see Robinson, 1998). Care must be taken in the reporting of our investigations and findings. We must know our audience.

This investigation was conducted for the purpose of improving the experiences of college students who begin their mathematics education at the developmental level. Hence, my target audience consists primarily of college and university mathematics teachers. As discussed in Chapter 1, many of these faculty are community college instructors and part-time employees. This project is

67
dedicated to these hard-working individuals and has been written for this particular audience.

**Participatory Action Research**

The methodology used to guide the current investigation followed a participatory action research design (see Reason, 1994). *Action research* refers to “a research strategy used to investigate schooling situations where the researcher assumes ‘wise practice’ that needs to be documented and understood” (Romberg, 1992, p. 57). *Wise practice*, in the case of the current study, refers to the design and implementation of the strategy-embedded developmental mathematics course. If low student achievement in developmental mathematics is due, in part, to students’ lack of knowledge of mathematics-specific study strategies, then strategy instruction will benefit the student. Data addressing this conjecture were documented and analyzed.

The impact of the students (co-researchers) on the current investigation qualifies this project as a participatory study. According to Glesne and Peshkin (1992), in *participatory research*,

> The investigation becomes an educational endeavor through analysis of the problems’ structural causes. It then becomes a process of collective action aimed at social change. Ideally, the researcher-researched relationship is marked by negotiation, reciprocity, and willingness on the part of all participants to change and be changed. (p. 11).

The voices, concerns, and conjectures of the student-participants in the current investigation influenced every aspect of this study—it was truly a collective action.
This chapter addresses the details of the current investigation—a participatory action research project.

**A Foundation for the Current Research**

Many of the methodological decisions described herein grew out of my own observations, experiences, and pilot investigations. According to Punch (1994),

> The personality of the researcher helps to determine his or her selection of topics, his or her intellectual approach, and his or her ability in the field. But often we are left in the dark as to the personal and intellectual path that led researchers to drop one line of inquiry or to pursue another topic. We require more intellectual autobiographies to clarify why academics end up studying what they do. (p. 86)

This is my attempt to enlighten those readers who are too often left in the dark.

As discussed in the first chapter of this dissertation, I have been working with students at the college developmental mathematics level for the past eight years. I have seen countless hard-working students struggling to succeed—sometimes with misdirected efforts, often to no avail.

It is my belief that most students who are enrolled in college developmental mathematics courses do not know how to approach mathematical study—they lack mathematics-specific self-regulatory skills. The pilot data reported in Chapter 1 support this claim. The current investigation is an attempt to address and document this void.

During the summer of 1996, I developed materials—modeled after resources from Dr. Claire Ellen Weinstein’s Learning-to-Learn Course (see
Chapter 2 of this dissertation)—for the purpose of teaching mathematics-specific learning strategies within developmental mathematics courses. These materials were piloted and subsequently refined. Revisions were based on recommendations and responses from students, colleagues, and other instructors who piloted these resources.

In addition, during the summer of 1997, I had the privilege of attending Dr. Weinstein’s annual training session for new instructors of her Learning-to-Learn course. During this 4-day workshop, I received intensive training on her Model of Strategic Learning (see Chapter 2) as well as pedagogical advice for teaching content-specific learning strategies.

Additional information regarding my personal views and theories can be found in Chapter 2—Making Explicit What Was Implicit. Further insight is offered throughout Chapters 4 and 5 in the context of researcher-teacher reflections.

**Research Questions**

The current investigation began during the fall of 1997. The primary research questions that were used to guide the investigation follow.

1. How do college students enrolled in a developmental mathematics course approach learning when mathematics-specific learning strategy instruction is embedded within the course? (See Chapter 4)

2. How do students who were enrolled in a strategy-embedded developmental mathematics course approach learning in their first college-credit
mathematics course if strategy instruction is no longer a course component? (See Chapter 5)

Additional research questions included:

3. What strategies do students who have been introduced to mathematics-specific learning strategies chose to employ?

4. Why are these particular strategies selected?

5. What factors facilitate or impede the use of such strategies?

The methods by which data were collected in order to address the aforementioned research questions are the main focus of this chapter. Detailed discussions of the participants and the various sources of data follow.

**Investigation Participants**

The participants in the current investigation included myself (the researcher-teacher), a class of my developmental mathematics students (n=19); a subset of my former developmental mathematics students (n=8); and a sampling of former developmental mathematics students who were never enrolled in any of my mathematics courses (n=4). The investigation took place at the Ohio State University during the 1997-1998 academic year.

**The Researcher-Teacher**

As one of the participants in the current investigation, I am obligated to further discuss my involvement. During the fall quarter of 1997, I taught a class of 19 developmental mathematics students (one of the groups of student
participants in the current investigation. The class met daily (Monday through Friday) for 10 weeks. Each class session lasted approximately 50 minutes.

A common syllabus and common examinations were used with this course. In other words, every instructor who taught this particular developmental mathematics course worked off of a standard syllabus and administered the same examinations (on the same days at the same times). Examinations were authored by a course coordinator (other than myself) and not made available to instructors prior to administration.

Instructor individuality was permitted with respect to instructional style—although time constraints typically forced the use of a lecture or a modified lecture format. In addition, approximately 8% of the students’ course grades were left to the instructor’s discretion. Some instructors graded homework. Others gave quizzes.

My students and I together determined the sources of this 8%. We decided that journal writing assignments (that focused on mathematics-specific learning strategies) and quizzes were the best options. The journal assignments are discussed in detail in the following chapter.

On a more personal note, as an instructor, my students describe me as “positive,” “caring,” and “a good teacher.” I am interested in the success of each and every student, and I am always available to provide additional support. My students are comfortable coming to my office and calling me at home with their questions.
The Students

Each of the participants in the current investigation enrolled in a developmental mathematics course at the Ohio State University during the fall of 1997. Students admitted to the Ohio State University take a locally-developed mathematics placement test. Placement in remediation is based on this test score. The content material covered in the developmental mathematics course includes: operations on real numbers; solving linear equations and inequalities; graphing linear equations; properties of exponents; and factoring polynomials.

Students Enrolled in the Strategy-Embedded Mathematics Course

During the fall of 1997, I taught a developmental mathematics course at the Ohio State University. In addition to the mathematical content described above, this course emphasized the development of mathematics-specific learning strategies. Nineteen students registered for this course and all 19 agreed to participate in the current investigation. At the time of enrollment, students were unaware that this course differed from any other developmental mathematics course. The details of this course as well as the students' responses to the mathematics-specific strategy instruction are reported in Chapter 4. A breakdown of the nineteen students by race and gender can be found in Figure 6.
Participation beyond the Strategy-Embedded Course

Eight of the 19 students who had enrolled in the strategy-embedded developmental mathematics course during the fall of 1997 continued to participate in the investigation throughout the winter and spring of 1998. Their approaches to studying in the absence of strategy-embedded instruction were examined. These eight students were selected because:

- They passed the developmental mathematics course and enrolled in a college-level mathematics course scheduled to begin during the Winter 1998 quarter;
- They represent multiple ethnic, age, and gender categories; and
- They demonstrated varied levels of achievement, class participation, and perceived use of self-regulatory strategies during their enrollment in my developmental mathematics course (Figure 7).
<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>Female</th>
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<tbody>
<tr>
<td>White</td>
<td>Tad (97%)</td>
<td>Kelly (83%)</td>
</tr>
<tr>
<td></td>
<td>Johnny (77%)</td>
<td>Mary (78%)</td>
</tr>
<tr>
<td>Non-White</td>
<td>Jake (74%)</td>
<td>Rachel (68%)</td>
</tr>
<tr>
<td></td>
<td>Donovan (65%)</td>
<td>Estelle (82%)</td>
</tr>
</tbody>
</table>

Figure 7: Breakdown of students who continued to participate in the study including their scores on the comprehensive developmental mathematics final examination.

This method of participant selection in qualitative research is known as purposeful sampling. According to Patton (1990):

The logic and power of purposeful sampling lies in selecting information-rich cases for study in depth. Information-rich cases are those from which one can learn a great deal about issues of central importance to the purpose of the research. (p. 169)

Purposeful sampling was also used in selecting the remaining four participants.

**Additional Participants**

Participation in the current investigation was not limited to students who attended the strategy-embedded developmental mathematics course. Four students who passed a developmental mathematics course at the Ohio State University during the fall of 1997, and enrolled in a college-level mathematics course during the winter of 1998 were also invited to participate in the investigation. These students
had been recommended by their former instructors as students who, "would be able to communicate their efforts." Two male and two female students volunteered to participate. Data collected from these participants were used to enrich and expand the primary research data.

**Openness**

Each of the participants in the current investigation was aware of the purpose of this study. The research questions were made known to these co-researchers so that they would be able to more completely address the interview questions. The students were continually reminded that I was interested in hearing about their lived realities—no information was bad information. Recommendations for conducting the investigation were accepted from the students throughout the course of this study.

**Ethics**

The current research investigation was conducted within the Human Subjects Guidelines of the Ohio State University. As previously stated, the participants were informed as to the nature of the investigation, and written consent was obtained from each of the study participants. The confidentiality of the participants has been respected throughout the course of this project. Pseudonyms were used on all documents and reports.
Reciprocity

The current investigation could not have been conducted without the student participants—my co-researchers. From these students, I received the information that I needed to support my dissertation research and to ultimately complete the requirements of my degree.

The twelve students who continued with the investigation throughout the winter and spring quarters of 1998 gave generously of their time. For this reason, I wanted to give something back to the students. Compensation was offered in the following forms:

- Students were paid $8 per hour for the time they spent interviewing;
- Review sessions were conducted by the researcher prior to the students’ final examinations in their college-level mathematics courses;
- Care packages were delivered to each of the participants during final exam week (winter 1998);
- An end-of-quarter dinner party honoring the study participants was prepared and served at my residence during the winter of 1998; and
- An end-of-quarter luncheon was hosted for the study participants at a local restaurant during the last week of the spring quarter of 1998.

Interestingly enough, some of these informal gatherings turned into information-rich sources of data. The more I gave—the more they gave.
Data Sources

The current investigation made use of four major sources of data. These sources include instruments, interviews, observations, and documents.

Instruments

Two types of instruments were used to support the current investigation. First, a commercial inventory intended to diagnose students' use of study strategies was administered to each of the participants prior to strategy instruction. Second, researcher-developed materials were used to support the teaching of mathematics-specific learning strategies in the developmental mathematics course.

Learning and Study Strategies Inventory (LASSI)

The Learning and Study Strategies Inventory (LASSI) (Weinstein, Shulte, & Palmer, 1987) is a 77-item self-assessment and diagnostic tool designed to measure students' use of learning strategies. The LASSI consists of ten scales; five scales measuring affective strategy use (attitude, motivation, time management, anxiety, and concentration), and five scales measuring cognitive strategy use (information processing, selecting main ideas, study aids, self-testing, and test strategies).

LASSI items are statements designed to elicit Likert-type responses ranging from "very typical of me" to "not at all typical of me." A sample statement follows: "When they are available, I attend group review sessions" (Weinstein et al., 1987, p. 6). This instrument is easily self-scored and yields ten individual scale scores.
Each of the ten scores can be graphed and compared to norming data included with the instrument. No composite score is computed. Students who score below the 75th percentile in any area should consider concentrating their efforts on improving strategy use in that area. Faculty are encouraged to provide prescriptive support.

According to the authors of the LASSI, the instrument is meant to be used as: (a) a diagnostic measure for identifying areas in which individual students may benefit from educational interventions; or (b) a pre-post achievement measure for students participating in learning strategies and study skills courses.

**Reliability.** Deming, Valeri-Gold, and Idleman (1994) investigated the reliability and validity of the ten subtests of the LASSI with college developmental students. The researchers obtained LASSI subtest scores from 99 developmental studies students in an urban two-year community college, and compared those scores with the norming values published by the authors of the LASSI (Weinstein et al., 1987). Deming et al. (1994) were concerned that the norming data reported in the LASSI "were not typical of high risk populations" (p. 312). The researchers found, however, that nine of the ten subtest reliability coefficients from their sample approached those reported by Weinstein et al. (1987). The subtest of Study Aids produced the lowest reliability coefficient and was significantly different from the Weinstein et al. (1987) data.

**Utility.** The utility of the LASSI as a means of measuring students' affective and cognitive growth was explored by Nist, Mealey, Simpson, and Kroc (1990). The researchers compared data from a group of regularly-admitted college students
(n=71) to data from a group of developmental studies students (n=68). All 139 students were enrolled in an 8-week study strategy course and took the LASSI as a pre-post measure. For both the developmental studies and the regularly-admitted students, results of an analysis of the change between pre-course and post-course LASSI subscores indicated that significant cognitive and affective growth had occurred.

**Pilot data.** During the winter of 1997, a group of 24 developmental mathematics students at the Ohio State University completed the LASSI (Smith, 1997). The instrument was administered on the first day of class and was used as a diagnostic measure. Most of the developmental mathematics students scored below the 75th percentile on more than half of the scales. These data were used to guide the development of a collection of interventionist activities designed to address mathematics-specific learning strategy deficiencies.

**Activities for Embedding Mathematics-Specific Learning Strategies**

As previously stated, materials intended to support the teaching and acquisition of mathematics-specific learning strategies were developed by the researcher (See Appendix B). These materials were piloted and refined prior to the start of the current investigation. Chapter 4 of this dissertation is devoted to the details of the strategy-embedded developmental mathematics. Hence, a discussion of these materials is found in the following chapter.
Interviews

Several types of interviews were conducted throughout the course of the current investigation (for example, individual, focus group, telephone, structured, and semi-structured). Kvale’s (1996) book on research interviewing and Morgan’s (1997) book on focus group interviewing were used as guides.

During the Strategy-Embedded Developmental Mathematics Course

Four focus group interviews were conducted throughout the fall of 1997 in the strategy-embedded developmental mathematics course. These whole-class prompted discussions regarding students’ progress and students’ reactions to strategy instruction were recorded, transcribed, and analyzed. The interviews took place during regularly scheduled class meetings on the class periods before each of the four major exams.

According to Morgan (1997), “the comparative advantage of focus groups as an interview technique lies in their ability to observe interaction on a topic” (p. 10). Similarities and differences in the perceptions and experiences of the participants are typically highlighted. A snowballing effect often occurs—“Oh, that reminds me...”

There are also disadvantages associated with the use of this interviewing technique. For example, in-depth personal accounts of experiences typically do not result from focus group discussions. Additionally, outlying views often remain unexpressed. For these reasons, focus group data collected during the
current investigation were supported by other methods (journal writing assignments, conversations with individuals).

**During the Quarters Following Strategy Instruction**

Each of the twelve students (8 students from the strategy-embedded course, 4 new participants) who participated in the current investigation during the winter and spring of 1998 were individually interviewed 3-4 times throughout the course of the investigation. These semi-structured interviews were audio recorded. Each interview lasted approximately one hour. Interview protocols consisting of both direct and probing questions (Kvale, 1996) were prepared by the researcher with the assistance of a group of colleagues (Appendix C).

**Rolling pilot.** Interview protocols were tested prior to their use. A former developmental mathematics student from the strategy-embedded course (Mark), who was not one of the eight aforementioned participants in the current investigation, was interviewed three times during the winter 1998 quarter for the purpose of refining interview questions. These interviews were recorded and reviewed by a colleague before each round of interviews with the twelve study participants began. This colleague helped me to recognize leading questions, reactions, and attitudes. The rolling pilot interviews also allowed me to preview possible interview themes.

**Initial interviews.** The initial interviews with the twelve student participants were conducted prior to the second week of classes of the winter 1998 quarter. During this interview, information about the student’s enrollment status (full time or
part time), academic major, and extracurricular activities (family, job, etc.) were gathered. The first half of the interview focused on a reflective account of the student’s approaches to studying mathematics during the developmental mathematics course (Math 050). Sample questions included:

- How did you approach studying in Math 050?
- Did your approaches to studying in Math 050 change as the quarter progressed?
- If yes, then how? Why?
- What advice would you give a friend who has just enrolled in Math 050?

The second half of the interview focused on the student’s goals and plans of action with respect to his/her current mathematics course (Math 104—College Algebra). Sample questions included:

- How will you approach (have you approached) studying in Math 104?
- What are your grade expectations in Math 104?
- How would you complete the following sentence: I know I can learn the material in Math 104 if...

Additional lines of inquiry were pursued based on individual student’s responses.

**Pre-examination interviews.** The twelve study participants were individually interviewed prior to each of the three major exams in Math 104. These interviews were conducted over the telephone. All interviews were recorded and transcribed. Students were asked about the strategies that they used in preparation
for each exam. For example:

- What did you do to prepare for the exam?

- How often did you go to your instructor's office hours (the math tutoring center, etc.) for help?

- How often did you study with a partner/group?

- What do you expect to find on the exam? Why?

Students were also asked to describe their confidence going into the exam and to predict their exam scores.

**Post-examination interviews.** In-person participant interviews were conducted after the administration of each of the three major exams in Math 104. Students' reactions to the exam were discussed. They talked about test items that were expected/unexpected and reflected on their pre-exam preparation. Students were also asked to discuss their plans of action for the remainder of the term and to compare/contrast this to their former approaches.

**Observations**

Observational data were also collected throughout the current investigation. During the strategy-embedded developmental mathematics course, observational field notes were maintained by the researcher. These notes included daily accounts of the progress of the course as well as impressions of classroom atmosphere. Additionally, twice during the fall of 1997, a member of the mathematics department faculty observed my developmental mathematics course. Observational
notes were collected from this individual regarding his impressions of the course and my instruction.

Observational data were also collected during the quarter following the strategy-embedded developmental mathematics course. Five times during the winter 1998 quarter, I attended my participants' Math 104 (college algebra) lectures. Two different classes/instructors were observed. This gave me the opportunity to evaluate the participants' notetaking strategies and abilities to select main points and key features of the lectures. I also looked for study-strategy cues provided by the Math 104 instructors. My observational notes contained the details of the content of the lectures as well as my own impressions and interpretations.

**Documents**

A variety of documents were collected and/or reviewed throughout the course of the current investigation. Many of these documents were used to substantiate (triangulate) the students' interview responses.

**During the Strategy-Embedded Developmental Mathematics Course**

Copies of all student journal responses and examinations were retained for analysis. Student projects directed at learning mathematics-specific learning strategies were also collected. Additional documents that were used to support the findings of the current investigation include copies of students' lecture notes, the course syllabus, the course textbook, personal communication traces (copies of email messages, phone logs, personal notes), attendance records, and course grades.
During the Quarter Following Strategy Instruction

The documents collected during the winter and spring quarters of 1998 included copies of the 12 students' lecture notes, homework assignments, and exams as well as the course syllabus, the course textbook, and additional materials distributed in the class (review sheets, etc.). Students' study logs were also collected.

Data Management and Analysis

The data collected throughout the course of the current investigation were stored in a locked filing cabinet at the residence of the researcher. All recorded interviews were selectively transcribed (Kvale, 1996) within three days of the interview. Interview data were maintained in both diskette and hard copy forms.

On-Going Data Analysis

Simply put, "data analysis involves organizing what you have seen, heard, and read so that you can make sense of what you have learned" (Glesne & Peshkin, 1992, p. 127). In qualitative research, data analysis is often done simultaneously with data collection. This allows the researcher to continuously reflect upon the data and modify the data collection processes, if necessary, as the investigation progresses.

Memo writing (Glaser & Strauss, 1967) is a way of developing your thoughts on paper in preliminary form. Throughout the current investigation, I maintained a reflective field log in an attempt to capture my impressions, ideas,
and thoughts as they occurred. As Laurel Richardson (1994) so pointedly stated, "I write because I want to find something out. I write in order to learn something that I didn’t know before I wrote it" (p. 517). Hence, the lines between data analysis and data collection/generation are often blurred.

Some of my field journal entries were transferred to notecards and stored in my analytic files (Glesne & Peshkin, 1992). *Analytic files* are useful when organizing and storing thoughts and ideas. These files may contain categories such as:

- Connections to theory;
- Quotations from the literature;
- Quotations from participants;
- Possible titles for chapters/dissertation;
- Researcher subjectivity; and
- Emergent themes;

These files continued to grow and the categories continued to expand as the investigation progressed.

**Coding and Categorizing**

In the current investigation, analytic files were used to assist in the development of rudimentary coding schemes for the research data. The transcribed interviews and other research documents were coded and categorized. Data from each source was copied onto colored paper—a different color for each
individual/source. Data were then stacked by category on the floor of my home office.

Special attention was given to the thick, multi-colored (multiple participant) stacks (although no stacks were discarded or completely ignored). Emergent themes were extracted from these stacks. These themes were used to form the basis for the cross-case analysis of the data (Huberman & Miles, 1994).

Data Presentation

It was not the goal of this research investigation to present a series of distinct case studies. Rather, a cross-case report drawing on key themes and issues is presented. A chronology technique (Glesne & Peshkin, 1992) for organizing portions of the text was used to emphasize the developmental nature of the learning-to-learn process. Throughout my writing, theory is discussed simultaneously with the research interpretations. Multiple theoretical lenses were considered in order to gain a richer understanding of the students’ use of studying strategies (theoretical triangulation).

Validity Concerns

The believability and trustworthiness of the data in any qualitative investigation are directly related to the methodological and analytical processes of the project. Four methods for increasing the trustworthiness of the data gathered and reported in the current investigation are discussed herein—triangulation, peer debriefing, member checking, and prolonged engagement. This section begins with a word of caution particularly relevant to the issue of validity.
Self-Report Data: A Word of Caution

Self-report data are often used when researchers investigate students’ use of study strategies. For this reason, Winne and his colleagues (Winne, Hadwin, Stockley, & Nesbit, 1997) designed a study to explore the reliability of students' self-reports. A group of educational psychology students (n=106) responded to a 3-part questionnaire describing their use of study strategies within the course. Students also reported the frequency of their engagement in each strategy.

Two chapters from the students' educational psychology textbook were xeroxed and distributed to the students. The first chapter addressed skills for learning; the second, basic concepts of motivation. Students were instructed to read the first chapter and then apply the strategies suggested in the first chapter while studying the next chapter. The researchers retrieved the xeroxed chapters and counted the traces of tactics recorded by students. These data were correlated with the self-report data. Overall, the researchers found that, "students' perceptions of how they study were quite inaccurate when gauged by traces of studying" (Winne et al., 1997, p. 4).

Triangulation

In the current investigation there was a concern that the data collected during the student interviews were untrustworthy for two reasons:

- As revealed by Winne et al. (1997), students’ perceptions of their own study strategies may be inaccurate; and,
In the case of this particular study, some of the students may have sought to impress the interviewer—their former instructor—with their responses.

In an attempt to address both of these issues, and as a way of increasing the trustworthiness of the data, information collected during the student interviews were *triangulated* whenever possible. Triangulation is a method by which multiple data sources are used to substantiate a claim or observation (Glesne & Peshkin, 1992). Observational data and documents were used to substantiate students’ interview responses (Figure 8).

![Figure 8: Triangulation in the current investigation](image)

**Peer Debriefing**

One of my colleagues reviewed several of the recorded interviews with me to discuss my responses and the possible effects of those responses on the interviewees. This colleague pointed out, for example, that I tended to talk more and to be more leading with the secondary participants (perhaps out of necessity). I attempted to refrain during subsequent interviews in order to increase the trustworthiness of the data. This method of increasing trustworthiness is known as peer debriefing. In addition, my preliminary coding themes were discussed with
this colleague in order to verify that I was not just “seeing what I wanted to see.”

**Member Checking**

The student participants were given the opportunity to either confirm or negotiate the interpretations and conclusions of the current investigation. This process—known as member checking—contributed to the face validity of the research, which is “operationalized by recycling descriptions, emerging analysis, and conclusions back through at least a subsample of the respondents” (Lather, 1986, p. 271).

**Prolonged Engagement**

A final method used to increase the trustworthiness of the data in the current investigation was prolonged engagement. I worked with most of the participants for more than six months and have been working at the research site for over three years.
CHAPTER 4

THE STRATEGY-EMBEDDED
DEVELOPMENTAL MATHEMATICS COURSE

_The question is not: Should we teach mathematics study skills? _
__but, rather, How should we teach mathematics study skills?_”
(Waycaster, 1993, p. 22)

Introduction

Support for learning strategy instruction can be found throughout the research literature. According to Svinicki (1991b), “We must help our students learn how to learn content, a step in sophistication above the mere learning of content itself (p. 29). Recently, the need for course-embedded strategy instruction has been emphasized. “Just as students can learn to become self-regulated learners, teachers can teach in ways that help students become self-regulated learners” (Pintrich, 1995, p.9).
Recommendations

Recommendations for embedding learning strategy instruction within content courses are also emerging in the literature. Pintrich (1995), for example, suggests that:

- *Students must become aware of their task-specific behaviors, motivations, and cognitions.* Instructors can use the Learning and Study Strategies Inventory (Weinstein, Schulte, & Palmer, 1993), for example, to facilitate this awareness.

- *Students must develop positive motivational beliefs.* Faculty can help students recognize that they are capable of learning and understanding course content.

- *Faculty can model self-regulatory skills.* This might include modeling thinking processes or even modeling specific skills such as reading in the content area.

- *Students must be given the opportunity to practice self-regulatory learning strategies.* This should take place over an extended period of time and include instructional supports and feedback.

While Pintrich (1995) offers generic recommendations for supporting student self-regulation, others offer domain-specific suggestions.
Schoenfeld (1992) asserts that the following mathematics-specific teacher behaviors and classroom practices can be used to foster the development of self-regulatory skills.

- *Faculty should make use of whole-class discussions.* Discussions can be used to highlight important data and processes as well as to assess students' understanding of these processes.

- *Faculty should use questioning to help students progress.* This technique can also be modeled and taught for the purpose of helping students to ask themselves good questions when they reach inevitable impasses.

- *Faculty should emphasize big picture ideas.* Helping students understand how content material hangs together should be a key feature of instruction.

The aforementioned recommendations, as well as the practical information provided by Dr. Claire Ellen Weinstein (see discussion in Chapter 2), have resulted in the design of the strategy-embedded developmental mathematics course described in this chapter.

**The Focus of this Chapter**

This chapter contains the details of the strategy-embedded developmental mathematics course taught at the Ohio State University during the fall of 1997. Nineteen students enrolled in this course. In addition to mathematical content instruction, students received training in the use of mathematics-specific learning
strategies. At the time of enrollment, students were unaware of the strategy-instruction component of this course.

The Students

The class consisted of eight male and eleven female students. The academic classifications of these students can be found in Figure 9. (Additional information about these student participants can be found in Chapter 3 of this dissertation.)

<table>
<thead>
<tr>
<th></th>
<th>Freshman</th>
<th>Sophomore</th>
<th>Junior</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>7</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Female</td>
<td>8</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

Figure 9: Breakdown of developmental mathematics students by classification

The majority of the freshmen had not officially declared a major, although most had unofficially done so. Areas of interest ranged from art to engineering to business. Physical therapy and optometry were also cited as possible avenues of pursuit.

Course Basics

The strategy-embedded developmental mathematics course operated within the normal constraints of any developmental mathematics course offered at the Ohio State University—no special concessions were made. The strategy-embedded
mathematics course met daily (Monday—Friday) for the entire 10-week quarter (9:30 to 10:18 a.m.). Students received five quarter-credit hours for this course. These hours were not applied toward graduation credit but did affect the students' grade point averages.

Three common examinations (100 points each) were administered throughout the quarter as well as one comprehensive common final examination (200 points). Exams were designed by the course coordinator and were not made available to instructors prior to administration. Attendance also contributed to the students' course grades (50 points), as did their homework and quiz averages (50 points). The only portion of the students' course grade left to the discretion of the instructor was the homework/quiz grade—which constituted less than 9% of the cumulative score.

The textbook used for this course was *Beginning Algebra (2nd Ed.)* by K. Elayn Martin-Gay (Prentice Hall, 1997). The first five chapters of the text were covered in the course:

- Chapter 1—A Review of Real Numbers;
- Chapter 2—Equation, Inequalities, and Problem Solving;
- Chapter 3—Graphing;
- Chapter 4—Exponents and Polynomials; and
- Chapter 5—Factoring Polynomials.
Students were given a detailed common syllabus on the first day of class—again designed by the course coordinator—that contained minimal suggested homework problems from the text for the entire quarter as well as a day-by-day breakdown of the material to be covered. Coverage averaged at a rate of one textbook section per day.

The Instructor

As the instructor of the strategy-embedded developmental mathematics course, I had prepared a variety of mathematics-specific study skills resources. I had several long-term goals prior to the start of this course. These goals included:

- *To tailor the course to meet the specific needs of the 19 students enrolled in the course.* This meant that I would need to be flexible, to really get to know my students. I might have to add new strategy-instruction components to the course and/or delete others.

- *To focus on the transfer of strategy use by the students.* The purpose of developmental mathematics instruction is to promote success in college-level mathematics courses. I wanted the students to see these strategies as tools for use in their next courses, not just as resources for developmental mathematics courses. Transfer would have to be emphasized throughout the quarter.

- *To scaffold instruction so that students would gain control over their learning.* By decreasing strategy-related requirements as the quarter
progressed, students would be allowed to make decisions about the effectiveness and continued use of these strategies.

This chapter details my efforts toward these goals. (Please refer to Chapters 1-3 for additional information regarding my background, qualifications, and interests.)

The Design of this Chapter

The details of the strategy-embedded developmental mathematics course are presented chronologically herein. A week-by-week account of the course is offered. This account includes:

- An overview of course content for the week;
- A description of the learning strategies discussed/used throughout the week;
- Samples of students' responses/reactions to strategy instruction; and
- Researcher-teacher reflections based on journal entries and links to literature.

The chapter concludes with a summary of the strategy-embedded developmental mathematics course and a synthesis of the data.

Week 1

The first few days of any class set the tone for the entire quarter. Students make decisions about courses and instructors relatively quickly. I like to open my classes by introducing myself—my background, my hobbies, and my interests—and asking the students to introduce themselves. Some students roll their eyes at this
request; others slump in their chairs—fearing any form of public oration. In the end, however, the room is always buzzing with conversation as students begin to bond with their classmates. A portion of this opening conversation (based on an audio recording) follows.

_Instructor:_ Why don’t you start by telling us your name, where you are from, and what you plan to study. Then tell us something about your own interests and hobbies—this makes it easier to get to know one another, to learn the names of your classmates. I’d also like you to say something about your relationship with mathematics...

_Katie:_ My name is Katie. I’m from Cleveland. I’m a freshman and I have no ideas what I’m going to major in...I can’t believe that I ended up in this math class...I feel really stupid for being here, but I guess it’s where I need to be...I don’t really like math, but I’m going to work really hard because I know I can do this.

_Janice:_ I used to feel like Katie—I mean I felt really bad that I ended up in this class—but I think it is good to have this review because then it will be fresh when I go to the next math class...

_Mark:_ I thought I was the only one who felt stupid about being in this class. I guess it is going to be okay...

Students were relieved to discover that they were not alone—others shared their fears, anxieties, and disappointments. They also discovered that some of their classmates were from rival high schools or neighboring communities. Initial bonds were forming. The students were even beginning to call each other by name. Research indicates that these types of experiences can positively affect achievement among underprepared college student populations (McMillon, 1994; Rendon & Fredrickson, 1993).
After the personal introductions were complete, I described the developmental mathematics course. Students were informed that this particular course would emphasize a mathematics-specific study strategies component. This component, they were told, would help them learn how to learn mathematics. They were also informed that as part of this instruction, it was going to be very important that I get to know each and every one of them, and that they get to know each other. The first few weeks of the quarter were devoted to the acquisition of this knowledge.

**Course Content for Week 1**

The first week of the quarter was devoted to a review of real numbers and their properties. This material did not particularly challenge most students. Topics included: symbols and sets of numbers; fractions; exponents and order of operations; variable expressions and equations; operations on real numbers; and properties of real numbers. I am always challenged at the beginning of any quarter to motivate student interest in developing appropriate study strategies because the students typically perceive the beginning content of the course as “stuff I already know—this is easy.” Jarod, one of the upperclassmen in the developmental mathematics course, offered the following advice to his classmates:

I’ve taken this class before and I made the mistake of thinking that it was easy—because it was at the beginning. So I didn’t really do much because I didn’t think I had to...but it gets a lot harder. That’s why I’m here for the second time. So don’t think that you can get by without studying, it gets harder and faster really fast.
I greatly appreciated Jarod’s advice. I could only hope that his classmates were listening.

Because of the nature of this beginning content material (review material), I was able to use the first half of each class period for a lecture-style presentation of the mathematics, and the second half of each class period for strategy instruction.

**Embedded Strategy Instruction Emphasized during Week 1**

As previously stated, the first week of the strategy-embedded developmental mathematics course was devoted to (a) helping me learn more about these particular students, and (b) helping these students learn more about themselves as learners. Additional resources and interventions would be determined based on this information. A summary of the resources used toward the attainment of these goals can be found in Figure 10. The resource referenced can be found in Appendix B.

<table>
<thead>
<tr>
<th>Week 1</th>
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<tbody>
<tr>
<td>Information Sheet ......................... Student Directory</td>
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<tr>
<td>Class Discussion: ........................ Asking for Help</td>
</tr>
<tr>
<td>Journal Writing Assignment ........... Mathematics Autobiography</td>
</tr>
<tr>
<td>Self-Evaluation Survey................. 11-Item Likert-Type Scale</td>
</tr>
<tr>
<td>Inventory ...................... Learning and Study Strategies Inventory</td>
</tr>
</tbody>
</table>

Figure 10: Summary of learning strategy component of course for Week 1
Students were asked to complete an information sheet on the first day of class. Information about each student's course load, class schedule, and work schedule (if applicable) was collected. I used these data to determine optimal office/consultation hours during the week. I found that most of my students were available immediately preceding and/or immediately following the lecture hour. These times became my established consultation periods. I was also available by appointment at other times throughout the day.

**Student Directory**

Students were also asked to provide their local addresses and phone numbers on these information sheets. The students were given the option to be listed in a class telephone directory that would be distributed to the entire group. All 19 students chose to be listed in the directory. I also included my office telephone number and home telephone number in this directory.

**Whole-Class Discussion**

A class discussion that focused on knowing when to persist and when to ask for help was initiated during the third class meeting. Students were encouraged to use their telephone directories to get help on homework problems before they reached the point of frustration. They were also encouraged to form study groups early in the quarter. Observational data collected throughout the quarter indicated that students made good use of this directory.

At the end of this discussion, students were asked how they could create similar support systems for themselves in their subsequent mathematics courses.
I wanted them to realize that instructor-initiated directories were not the norm. They suggested:

You could ask the people that you sit beside in lecture if they wanted to trade phone numbers...You could sign up for the class with a group of people you already know...You could still study with these same people even though they’re not in your same class.

I openly emphasized the need to reuse any strategy that “worked for them” as they continued to progress through their mathematics courses. According to Svinicki (1991), the transfer of strategy use to new contexts is not automatic—“provisions must be made during initial learning for later transfer” (p. 33).

**Mathematics Autobiographies**

The mathematics autobiography journal-writing assignment was used to introduce writing in the domain of mathematics and to gather baseline information concerning students' beliefs about themselves as doers of mathematics as well as students' beliefs about the nature of mathematics. Students were given this assignment on the first day of class. They had three days to complete their autobiographies. The following journal writing prompt was issued:

Describe (chronologically, if possible) your previous experiences with mathematics. Where have you been? Where are you going? Where are you now?

Whenever I read my students' journal responses, I always read for content only. In other words, I do not correct spelling or grammar because I do not want to draw the students' attention away from the purpose of the assignment (a decision
based on my own personal theory). I provide extensive written feedback—a personal dialogue with the student—on each journal. I also look for themes that crosscut the journals and discuss these themes with the entire class.

**Student autobiographical data.** Before discussing the key themes and issues that were found throughout the student mathematical autobiographies, it is useful to examine a sampling of the students’ writing. This subset is intended to provide the reader with an insider’s view of these particular students.

**Lenora:** My first memory of mathematics is of my mother teaching me how to count when I was little. Math and I did not have a problem with one another through grade/elementary school. I used to get excellent grades in math up until high school. The only problems I would have was with story problems. I could never seem to get them for anything. I decided right then and there that they were my worst enemy when it came to math. The first time I felt that there was something wrong with my comprehension of math was when I failed the math section of the 9th grade Ohio proficiency test. I passed every other part but math, and you had to pass all four parts in order to graduate. I had to take the math section two more times before I passed it. Also, my math grades in high school were beginning to suck! There was something about incorporating letters with numbers that just did not appeal to me. I was also one of those people that hated tutors, so I never had one. I never got help, and I got through Algebra I, Geometry, Algebra II and Trigonometry with D’s. So here I am in college wondering why I didn’t place into a high math class. It’s because I didn’t learn the math I needed to in high school. I wanted to be a doctor of marine biology for the longest time. But because my math has been so bad, that career goal has kind of gone down the drain. I really want to succeed in math. I guess I just get so frustrated sometimes. I feel that it is going to take a lot of time and patience for me to really understand the concepts of mathematics. I am willing to try and to do the best that I can. That is all that I can ask of myself.

**Lisa:** When I first started mathematics I was always placed in the highest math class, all the way to my freshman year in high school. At
first I was put in the top class but then my grades began to slip. I had a very hard freshmen year in the fact that I didn't see the importance of grades and put all my energy into making friends and getting involved in sports and extracurricular activities. After a while I got placed into the lowest class of math and that changed my attitude and the attitude of everyone around me. All of a sudden my teacher treated me as dumb and if I got good grades she would act like I cheated. My mom would cringe when I had a math test. I lost all confidence in math and I got frustrated easily so I started to hate math with a passion. All through high school my math grades were low and I was always in the lowest class.

Johnny: In high school, I was in Algebra I, Algebra II, and geometry. I received, or earned, an A in all three classes. I took these in 9th grade until my junior year. I didn't take any math classes in my senior year, last year, of high school. This is why I believe I am in your class. Your class is my favorite class of my new classes. I'm glad to have you as a teacher, and hopefully if I need help, I feel that you will help me in any way you can. Hopefully, I will be able to go on to take any math class I need for my major or just for fun, but right now, I need to polish up my math operations, so I can do what I want in the future.

Kelly: During high school I took Algebra I, Algebra II, and Geometry. I averaged a B- to C+. I think that this math will be a good warm-up for me considering I haven't had math since my junior year. I enjoy doing math but if I don't understand I get upset. But I know if I need help I will ask you or find a study buddie. And also I get very nervous around exam time and quizzes.

Jarod: For the most part I am good in mathematics. I always did pretty good in math in high school. I was not in calculus or anything but I did not take easy math classes. I averaged about a B in all my math classes. I took this course last quarter. I did not do so hot. I just did not take it serious, because I was like that is going to be easy, but it was not. I would do the homework and it was pretty easy, but then when the exams and final came around I didn't do good on them. But I was out of school for about 9 months so that could have been some of it too. I want to get an A this quarter. I have many math courses ahead of me for my degree (business). Plus I think this quarter your class will be better than my last quarter math class. The students were not involved in class. I plan to do much better this quarter. I think that we should turn in
our homework because I do not think I would do it if there is not a reason to do it.

Amy

My previous math experiences through high school were very good, I thought. But then I placed into this class. When I do my homework I feel as if I know what I am doing, but when I go to take a test, I get a lot wrong. So I really don't know where exactly I stand at this point, but I would really like to do well in this course and come out with an A. So I am open to suggestions that you might feel will be helpful for me to do well in the course.

Estelle:

In high school and my years before I did pretty well in math. I never really understood the concepts but still received A's and B's. I never do good on math tests, which were always my big problem. I would do good on homework and class discussion, but I don't know what happens when it comes to math tests. I've never known how to study for a math test, so I never studied.

I always learn so much about my students from their mathematical autobiographies.

**Autobiographical themes.** The student autobiographies were coded and analyzed in search of themes and issues that might be used to guide strategy instruction. Several themes emerged, as described below.

Most students articulated their own theories about why they believed they had tested into a remedial mathematics course—*I was never good at math*, or *I haven't taken a math class in several years*, or *I had a bad teacher*. Many of these theories revealed that students felt that success was out of their control—*If I get a good teacher, then I will pass my math class*, or *If someone makes me turn in homework, then I will do it*.

Instruction in my course would need to focus on helping students gain control over their own learning in mathematics. This would require providing the
students with a repertoire of strategies from which to choose. Students who felt helpless because they “never knew how to study mathematics” would gain a sense of direction and control.

Students’ self-efficacy beliefs were also revealed in their statements. For example, I am horrible at math, or Math is one of my strengths so I feel confident that I will do well. Instruction would need to foster positive, but not unrealistic self-efficacy beliefs.

Many of my students also mentioned mathematics test anxiety in their autobiographies. They talked about doing well in class and on homework assignments, yet still failing examinations. In order to address this problem students would need extensive instruction on self-monitoring and self-assessment. I believe that, in most cases, when a student fails an exam, he/she was typically not as prepared as she/he believed him/herself to be (another personal theory).

Autobiographical data also revealed an overall positive attitude toward the current strategy-embedded developmental mathematics course. Many students had incorporated information from the earlier class discussion on Asking for Help within their “plans” for succeeding in the current course. They were also beginning to ask questions about what they could do to help themselves succeed.
Self-Evaluation Survey

On the first day of the developmental mathematics class, each of the 19 students completed an 11-item Likert-type survey. Students were asked to respond to a series of statements by placing an “X” on the partial number line above each statement ranging from “0” (strongly disagree) to “10” (strongly agree). For example:

![Number Line with Scale]

I KNOW HOW TO STUDY MATHEMATICS

Figure 11: Sample survey item

Students’ responses to this survey were collected and retained by the instructor. Students were also asked to complete the same survey at the end of the quarter (see Week 10). These responses were then compared to the original data. The 11 statements found in this survey are:

1. I usually have a difficult time understanding mathematics.

2. I am confident in my ability to perform well on a mathematics test.
3. I know how to study mathematics.

4. I am good at mathematics.

5. I usually ask questions when I do not understand.

6. I know where to go for help.

7. When a mathematics problem is difficult I can learn how to do it.

8. I am easily discouraged when working on a mathematics problem.

9. Learning mathematics is important to me.

10. Getting good grades is important to me.

11. My success in mathematics depends heavily on the instructor.

A graph of students’ responses to this survey is located on the following page (Figure 12).

**Summary of students’ responses.** Figure 12 provides a summary of the students’ initial responses to this survey. Overall, students felt that learning mathematics was very important (9); that getting good grades in mathematics was also important (10); and that their success in a mathematics course was heavily dependent on the instructor (11). Most students felt that they had a difficult time understanding mathematics (1) and that they really did not know how to study mathematics (3). Data also indicate that many students do not ask questions when they lack understanding (5) even though most had some idea where to go for help (6).

**Impact on instruction.** These results indicate, similar to the autobiographical data, that students typically view their success in a mathematics
course as heavily dependent on external sources—the instructor, for example. Encouraging students to ask questions and seek help—to take control of their own learning—might serve to decrease this external focus. Student responsibility and decision making would need to be emphasized throughout the course.

**Learning and Study Strategies Inventory (LASSI)**

The Learning and Study Strategies Inventory (LASSI) (Weinstein, et al., 1993) provides students with information about their current use of learning strategies. According to the authors,

> The LASSI is an assessment tool designed to measure students' use of learning and study strategies and methods. It is a diagnostic and prescriptive measure. The focus is on both covert and overt thoughts and behaviors that relate to successful learning and that can be altered through educational interventions. Thus, both student thought processes and behaviors are assessed. In addition, these thought processes and behaviors contribute significantly to success in post-secondary educational settings and can be learned or enhanced through educational interventions. (LASSI User’s Manual, p. 2)

The LASSI yields 10 distinct percentile scores, one for each of the 10 scales: Attitude (ATT), Motivation (MOT), Time Management (TMT), Anxiety (ANX), Concentration (CON), Information Processing (INP), Selecting Main Ideas (SMI), Study Aids (STA), Self Testing (SFT), and Test Strategies (TST). According to the authors of the LASSI, this instrument can be used as a basis for planning individual prescriptions for remediation programs.

**LASSI results of the study participants.** Each of the 19 developmental mathematics students completed and self-scored the LASSI. Their responses are summarized in Figure 13. Percentile scores, based on national norms, were
<table>
<thead>
<tr>
<th>RAW SCORES</th>
<th>75th AND 50th PERCENTILE CUTOFF SCORES</th>
<th>SAMPLE MEAN</th>
<th>SAMPLE STANDARD DEVIATION</th>
<th>MEAN PERCENTILE RANK</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATT</td>
<td>24 29 29 30 31 31 32 32 32 32 32 32 33 34 34 35 35 35 37 37</td>
<td>75th 35</td>
<td>32.263</td>
<td>50th 50th</td>
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<tr>
<td></td>
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<td>50th 32</td>
<td>3.1063</td>
<td></td>
</tr>
<tr>
<td>MOT</td>
<td>15 15 16 19 20 22 22 23 24 24 25 25 26 26 27 28 28 29 29 31 31 31 31 31 31 31</td>
<td>75th 34</td>
<td>30.526</td>
<td>45th 45th</td>
</tr>
<tr>
<td></td>
<td>26 26 27 28 28 28 32 32 32 32 32 32 32 32 32 32 32 32 32 32 32 32 32 32 32 32</td>
<td>50th 26</td>
<td>5.8679</td>
<td></td>
</tr>
<tr>
<td>INP</td>
<td>13 14 14 14 16 16 17 18 19 19 19 19 19 20 21 21 21 22 22 22 22 22 22 22 22 22 22</td>
<td>75th 30</td>
<td>24.895</td>
<td>35th 35th</td>
</tr>
</tbody>
</table>

ATT—attitude and interest  MOT—motivation, diligence, self-discipline, and willingness to work hard  TMT—use of time management  ANX—anxiety and worry  CON—concentration and attention  INP—information processing, acquiring knowledge and reasoning  SMI—selecting main ideas and recognizing important information  STA—use of support techniques and materials  SFT—self-testing  TST—testing strategies and preparing for tests

Figure 13: Summary of student responses on the 10 scales of the LASSI
assigned to each of the 10 scales of the LASSI. Percentile data are also reflected in Figure 13. Dr. Weinstein recommends a cut-off score of 75% for determining intervention needs. In other words, for each scale in which the student scores below the 75th percentile, intervention is probably necessary.

**A summary of the LASSI data.** The LASSI scores, as reported in Figure 13, were quite discouraging. It seemed that the developmental mathematics students needed instruction and support with respect to each of the 10 scales. Most students scored below the 75th percentile across the board. Many scored below the 50th percentile. On a more positive note, it was obvious that any type of strategy instruction that was offered as part of the developmental mathematics course would benefit the majority of students.

**Researcher-Teacher Reflections**

The first week of class had gone by quickly. I had collected and analyzed quite a bit of data, and I had already begun to work toward one of my long-term goals: *To tailor the course to meet the specific needs of these 19 students.* Student responses were very positive. The developmental mathematics students seemed to understand why we were doing what we were doing. I was encouraged by an email message I received from one of the students during this first week:

Ms. Smith, I just wanted to thank you for all the time and effort you have put into this course. I can tell you really care about your students and that you are going to help us become successful. It’s nice to find someone who is really interested in helping out—and based on my LASSI scores, I need quite a bit of help. Kelly
Attendance during the first week was near perfect. Students were completing the writing assignments, inventories, and surveys and returning them on time. We were off to a good start.

**Week 2**

The first week of class had been devoted to introductions—introducing the class and getting to know one another. Instruction during the second week would focus on basic strategy instruction specific to mathematics—using a mathematics text and taking notes during a lecture, for example. The students needed to be introduced to these strategies early in the quarter so that they would be able to use and refine these skills throughout the term. I am reminded by Pintrich (1995), that acquisition of learning strategies and skills takes place over an extended period of time and is dependent on sufficient practice.

**Course Content for Week 2**

Content instruction during the second week of the quarter focused on equations and problem solving. Topics included: simplifying algebraic expressions; the addition and multiplication properties of equality; solving linear equations; formulas and problem solving; and percent and problem solving. The students found this material to be more challenging than the earlier review of real numbers (Week 1).

As we began the second week of classes, we also started the countdown to the first major examination—scheduled to take place during Week 3. The students were motivated to learn. The introductory content covered during the first week of
classes seemed to boost self-efficacy perceptions—"I can do this stuff as long as I keep up with it." Additionally, most of the anxieties associated with a new course/instructor/quarter were dissipating.

**Embedded Strategy Instruction Emphasized during Week 2**

Strategy instruction during the second week of class focused on meeting students' individual needs with respect to learning strategy instruction (LASSI-related activities) as well as addressing basic learning strategies that are often assumed to be known, understood, and used by mathematics students (how to read a mathematics text, for example). A summary of these activities is found in Figure 14 (see Appendix B for copies of these resources).

<table>
<thead>
<tr>
<th>Week 2</th>
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<tbody>
<tr>
<td>Class Discussion ............................................. LASSI Plus</td>
</tr>
<tr>
<td>Journal Writing Assignment .......... LASSI: Focussing on One Scale</td>
</tr>
<tr>
<td>Class Discussion ................................. Homework Grading Policy</td>
</tr>
<tr>
<td>Class Discussion .............................. Investigating Textbook Features</td>
</tr>
<tr>
<td>Homework ........................................... Reading a Mathematics Text</td>
</tr>
<tr>
<td>Lecture............................................... Notetaking in Mathematics</td>
</tr>
<tr>
<td>Class Discussion ................................. Missing a Lecture</td>
</tr>
</tbody>
</table>

Figure 14: Summary of learning strategy component of course for Week 2
Exploring the LASSI

The ten scales on the Learning and Study Strategies Inventory (LASSI) were discussed in class. Students were informed that the instrument is not an intelligence test, and that the ten components of the LASSI are related to academic success and amenable to instruction. A summary of students’ responses to the LASSI was presented to the entire class. This was a judgment call on my part—I wanted the students to know that they were not alone, that others had also scored in the lower percentiles on many of the scales.

A mathematics lesson. In order to help the students better understand their scores (and because, after all, this was a mathematics class), I presented a brief mathematics lesson related to the LASSI on percentiles—how they are calculated and what they represent. Shawn pointed out another added benefit to this discussion when he said, “It’s nice to see that some of this math is good for something.”

Journal writing assignment. Each student was asked to select one of the LASSI scales to focus on for the following two weeks. A summary of student choices can be found in Figure 15. Six different scales were selected with most students choosing SMI (selecting main ideas) or TST (test strategies and preparing for tests). In a journal writing assignment, each student identified her/his area of focus and wrote about his/her plan of action for improving skills/strategies related to this area.
**Instructional feedback and support.** I responded to each of their journal entries with recommendations and support materials when applicable. Using Dr. Weinstein's Learning-to-Learn course packet as a major resource, I created instructional handouts for the students who had indicated ATT (attitude and interest), ANX (anxiety and worry), or CON (concentration and attention) as their areas of concentration. For the student who selected STA (support techniques and materials), I offered a list of resources available to mathematics students and instructed the individual to explore at least three of these resources and report back to me. Selecting main ideas (SMI) and test preparation strategies (TST) would be emphasized during whole-class instruction throughout the quarter.
Negotiating a Grading Policy

The allocation of the 50 points (approximately 8% of the course grade) left to the instructor’s discretion (and typically used as a homework/quiz grade) was jointly determined. After describing some of the things I had done in the past with respect to this portion of the course grade, students were asked to come up with three possible options. The class voted (secret ballot) on these options, and the following grading policy was determined. Weekly quizzes would account for 25 of the 50 points, and journal writing assignments and projects related to the learning strategy component of the course would account for the remaining 25 points.

The students voted to have open-notebook homework quizzes. I would select one or two problems from each homework section discussed during the previous weeks lectures, and the students would show those particular problems (using their homework notebooks, but not their textbooks) along with all the necessary solution details on the quiz. If the student had completed the entire homework assignment and checked the answers with those in the back of the book, then she/he would be guaranteed a perfect score on the quiz. The students believed that this policy would motivate them to complete the homework assignments and check their answers (a strategy students often neglect).

Journal writing assignments and other projects would be graded as either complete (full credit) or in-progress. Work that was considered to be “in-progress” could be resubmitted for full credit. Examples of “in-progress” work might include
student journal entries in which the student did not respond to all the prompts, or student writing that required clarification or continued dialogue.

**Mathematical Textbooks**

Consider the following quotation from Johnson (1984): “[Mathematics texts] are often filled with precise technical vocabulary. Pages are densely packed with ideas, with concepts that must be applied, not just remembered. Even more difficult are the maze of symbols, signs and abbreviations” (p. 604). It is my opinion that mathematics textbooks have come a long way since 1984, and perhaps Johnson’s statements no longer apply. I read the citation to my students. They whole-heartedly agreed with *her* observations.

**Investigating textbook features.** Reading a mathematical text can be quite challenging. Students often do not know where to begin. As a way of introducing this topic, the students were instructed to read the author’s *Letter to the Student* found in the front of their course text. The class then discussed the various features of the textbook described in this letter. They were amazed to discover the resources available in the book—summaries, practice tests and reviews, vocabulary cues, and calculator support, to name a few.

Vernon asked if all math books had this kind of stuff in them. I told the class that I would bring in copies of the math book used in the following course for their review. The students reported finding similar features in this text. I was pleased to find that the students were interested in the continued use of these resources/strategies.
**Modeling reading a mathematical text.** Instead of presenting a lecture on solving linear equations, I copied the corresponding textbook sections onto overhead transparencies. I used these pages to model reading (and learning from) a mathematical text. I explained that the top-to-bottom, left-to-right approach to reading does not always apply to technical texts. The students watched as I identified key topics, periodically checked my understanding, worked through the examples with pencil in hand, and created a list of questions that needed to be clarified.

Kelly commented, "I can't believe it took 30 minutes to read three pages!" Jake said that he probably would have gotten frustrated and given up if he had been doing this on his own because he would have expected to spend less than five minutes reading those pages. I had not considered the frustrations associated with misconceptions of this nature.

Two additional sections from the students' current textbook (formulas and problem solving; and the rectangular coordinate system) were selected for which no lecture was presented—students were responsible for reading the examples in the text and bringing specific questions to class for discussion. In practicing this strategy—reading a text—students found that they were able to use their books as resources.

There is evidence to suggest that at least some of the students continued to use their textbooks as resources even when they were not specifically instructed to do so. On five different occasions during the quarter, students who had missed a
class meeting took it upon themselves to read the corresponding textbook section and then telephone me regarding their specific questions.

**Learning from a Lecture**

The lecture method of instruction is the most common method of delivery in postsecondary mathematics classrooms. An informal survey revealed that most of the 19 developmental mathematics students had attended lecture-style high school mathematics classes. When I asked the students if they had taken notes in their high school math classes, they replied that they had. I was not surprised to discover, however, that most of the students reported that they never actually used their notes.

**Notetaking instruction.** Students were given a template for organizing notes in a mathematics lecture (Figure 16). Lecture-style lessons were presented using this template for the first half of the quarter to assist students in their efforts. Students were encouraged to label their notes in some fashion (date, topic, etc.) and to create an index in the left margin to facilitate review (definition, example, formula). It was also suggested that the far right margin be used for secondary notes—questions/comments that arose during study and review.

Students initially reported that this form of notetaking was time consuming—"*Do we have to do it this way?*" I encouraged them to persist for the next two weeks. At the end of this period, students were asked to evaluate their notes and create their own templates. Fourteen students reported that they were happy with this method—that it was working for them—and continued to organize their notes in this manner.
In addition to taking good notes, students were instructed to *use* their notes. Lecture notes could be used as a warm-up before beginning homework assignments or as a review for upcoming exams. Lisa reported, "*This is really cool, my notes look so good, I actually want to use them.*"

**Missing a lecture.** It is inevitable that most students will miss a class meeting or two. The 19 developmental mathematics students were asked to develop their plans of action in the event they missed a mathematics lecture. Their plans most often included: calling a classmate to obtain the notes; reading the appropriate section in the textbook; going to the instructor's office hours; and/or visiting the mathematics tutoring lab.
Student 1: This seems like a lot of trouble, like it would take a lot of time. I think it would be better if you just didn’t miss class at all.

Student 2: If you do miss class then you’ll be lost the next time you go if you don’t get caught up and sometimes you get sick and you just can’t go so at least you can try to keep up on your own.

Researcher-Teacher Reflections

Although students were still enthusiastic about the course and the embedded strategy instruction, I sensed a small amount of mild resistance during this second week. The group was beginning to realize that strategy use was effortful—It’s hard to take good notes, and difficult to read a mathematics textbook. I, too, began to realize that strategy instruction was effortful—it took a lot of preparation time outside of the classroom. I was certain however that things would get easier for all of us as the quarter progressed.

Week 3

The new course content introduced during the third week of the quarter was minimal—one section on solving linear equations. Most of the week was spent reviewing for and taking the first major examination.

Embedded Strategy Instruction Emphasized during Week 3

Strategy instruction during the third week of the quarter focused on helping students prepare for their first mathematics examination and encouraging students’ self-reflections and self-analyses. Refer to Table 17 for a summary of activities.
Preparing for a Mathematics Exam

On the Monday before the first exam (scheduled to take place on Wednesday), I posed the following question to my class: *How do you think mathematics instructors prepare exams for their students?* The following responses were offered.

*Student 1:* They go through the book and pick out all the hardest problems.

*Student 2:* They find problems with tricky parts to them.

*Student 3:* They pick out a few easy ones so everyone doesn’t fail.

These answers might explain why students typically report studying “hard” problems when preparing for mathematics tests (Smith, 1997a).

**Exam-writing tactics revealed.** Throughout the quarter, I emphasized *big picture ideas* (on the notetaking template, as part of my lecture structure). I was always asking the students to identify the main points of a lesson. For example, during the first week of the quarter instruction focused on real numbers and their operations (the big picture idea). Some of the specific lessons dealt strictly with
whole numbers while others dealt strictly with fractions (subtopics within the big picture). Within each of these subtopics, specific mathematics problems can be identified (examples). These structures (big picture ideas, subtopics, examples) were made explicit during lecture.

As part of our examination review, I asked the students to consider all the material we had covered since the beginning of the quarter and to identify the “big picture ideas.” Students responded to this request rather quickly since the notion of “big picture ideas” had been emphasized all quarter. The students decided that the main ideas covered so far this quarter were operations on real numbers, and solving equations.

*Instructor:* How would you have known that these were the main ideas if I hadn’t repeatedly told you so?

*Student:* That’s easy. They’re practically the titles of the first two chapters in our book.

*Instructor:* Could we use the book to help us identify the subtopics?

We filled the chalkboard with main ideas (2), subtopics (16), and specific examples. We then dissected an old examination (prepared and administered one quarter earlier, and made available to all students for under $2—copying costs). Students found that the questions were distributed relatively evenly among the subtopics.

I recalled a statement made by one of my colleagues (in reference to test creation strategies): “Do we really want to let our students in on all our secrets?”

Yes, we do! I again asked my class: *How do you think mathematics instructors prepare exams for their students?*
Student: It's obvious now, I think we all get it. They look at main ideas and stuff.

Instructor: How can we use this information to help us prepare for the upcoming exam?

Proposed study strategies. Amy suggested that a checklist would be one way to approach studying—“You could look at all the subtopics and check off all the ones that you already understand and then study the ones that you don’t.” Other students suggested that making out sample tests would be useful. All of these options were encouraged.

Reflecting on Exam Preparation Strategies

After the students took the first examination, but before the examination results were reported, a whole-class discussion (focus group interview) was initiated. Students were asked to discuss their study strategies and exam preparation strategies with respect to this course.

Student 1: First of all, the exam was exactly what I expected—following the book and all. I think I did O.K. I like the way the class is going so far.

Student 2: I like having the phone list because a group of us got together to study the weekend before the test and I think that really helped. My notes were also helpful.

Student 3: I think that you [the instructor] have a lot of really good ideas and all, and I wish I had time to do that stuff, but I just don’t. I barely have time to do the homework. But I still think they’re good ideas.

Student 4: It really helps that we all know each other and talk a lot. I use those phone numbers all the time. If I get stuck on something I just call someone. I mostly studied the main ideas we talked about in class and I studied with Jake and Vernon—that was good.
Most students talked about following main idea cues in preparation for the exam. Two study groups (4 students in each) had already been established. Fifteen of the 19 students reported using the student telephone directory at least once during the quarter. Students also reported that they were actually using their notes as a study aid.

**Journal writing assignment.** Students were also asked to reflect on their exam preparation experiences in writing. The following questions were posed:

- When (if ever) did you purchase the sample examination?
- Was the actual exam what you expected? Explain.
- What did you do to prepare for this exam?
- What do you wish you would have done differently (if anything)?
- What grade do you expect to receive?
- What do you think you missed on the exam? Why?

According to Kusnic and Finley (1993), through “self-evaluation assignments, we pose students’ own learning as a problem to be solved. We challenge students to name and validate their own experience and to create a more conscious sense of their authentic selves” (p. 13).

**Student responses.** Approximately one-third of the students in the class reported purchasing the sample midterm (for under $2) at the beginning of the quarter when they first heard about the resource. Another third of the class
reported buying the sample test one week before the actual exam. The remaining students reported that they had yet to purchase the sample exam.

With respect to the students’ expectations (Was the actual exam what you expected?), 13 of the 19 students reported that the exam was exactly what they expected:

_Mary:_ I think it was what I expected because the practice test covered everything that we needed to know.

_Rachel:_ It was exactly like I expected. It was in the same format as our review.

Five students reported that the exam was _somewhat_ what they expected. One student, Johnny, felt that the exam was nothing like he expected because, according to Johnny, “the exam I expected to get would be a lot harder than the one we just took. I thought there would be more problems dealing with solving equations.”

The strategies students reported using in preparation for this exam included: reviewing the sample test; attending lectures; completing homework assignments; and reviewing class notes. Students also confessed that they wished they would have: purchased the sample tests earlier; reviewed particular sections in the text; paid closer attention during lectures; and asked more/better questions.

When predicting examination grades, most students accurately foreshadowed their results—although students who scored 90% or better on the exam tended to slightly underestimate (under-report) their success. Two students, however, completely “missed the mark” with their predictions, Johnny and Vernon.
Johnny—the student who thought the exam was much easier than he expected it to be—predicted a “B” examination grade. His actual score, however, was only 66% (a “D”). Johnny’s journal revealed that he was “unsure of 5 problems on the exam.” He did miss the five problems he mentioned in the journal, plus three others.

Vernon knew that he had “mixed up the ideas about how to solve [certain types of problems, and probably missed] about 3 questions,” but he was not expecting a 62% (low “D”). Vernon had also predicted a “B” examination grade. An interesting side note—both Vernon and Johnny reported that they did not purchase the practice exam and wished they had done so.

**Examination Results and Analyses**

As previously stated, developmental mathematics examinations at the Ohio State University are written by a course coordinator and not made available to instructors prior to administration. Scoring is done by individual instructors with the aid of a detailed scoring guide—very little partial credit is awarded and instructors must contact the coordinator before deviating from the scoring guide.

**Results.** The median score on Exam 1 reported by the mathematics department for 397 of the 465 students who took the exam was 70% (data from two instructors were unavailable). The students enrolled in the strategy-embedded developmental mathematics course had a median score of 73.5%. A more detailed comparison can be found in Figure 18.
<table>
<thead>
<tr>
<th>Grade</th>
<th>Number of students</th>
<th>Percentages</th>
<th>Number of students</th>
<th>Percentages</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>40</td>
<td>10.58%</td>
<td>2</td>
<td>10.53%</td>
</tr>
<tr>
<td>B</td>
<td>83</td>
<td>21.96%</td>
<td>4</td>
<td>21.05%</td>
</tr>
<tr>
<td>C</td>
<td>87</td>
<td>23.02%</td>
<td>9</td>
<td>47.36%</td>
</tr>
<tr>
<td>D</td>
<td>66</td>
<td>17.46%</td>
<td>2</td>
<td>10.53%</td>
</tr>
<tr>
<td>E</td>
<td>102</td>
<td>26.98%</td>
<td>2</td>
<td>10.53%</td>
</tr>
</tbody>
</table>

Figure 18: Descriptive statistics of Exam 1 grades

These results were encouraging. Approximately 79% of the students enrolled in the strategy-embedded course had scored a C or better on the exam, compared to only 56% of the remaining population of developmental mathematics students (see Figure 19).

Despite these relatively positive results, many of my students were disappointed with their grades. Previous experience tells me that students who are unhappy with their examination results typically file their exams away in a folder or drawer without reviewing or analyzing their mistakes. A self-evaluative assignment was created to encourage students to review their exams, analyze their mistakes, and correct their errors and misconceptions.

**Exam correction and analysis assignment.** Exam items were graded as correct or incorrect. No other feedback was offered. Students were required to
Figure 19: Comparison of grades on Exam 1
correct and analyze their own mistakes. The purpose of this assignment was to promote student self-evaluation and self-reflection as well as to enhance content knowledge. Students were required to:

- Correct any problem on the exam that they lost any points on; and
- Write a brief statement about what went wrong.

Students were encouraged to work together, talk to me, or seek any additional assistance they deemed necessary.

**Student responses.** When this assignment was initially turned in, more than half of the students merely corrected their exams—they did not analyze their mistakes. The assignment was returned and students were instructed to complete the analysis portion. It appeared that many of the students had placed little or no value on this part of the activity.

My insistence paid off. Students began to report that, in many cases, they discovered that they were making the same careless errors over and over again.

*Rachel:* Every time I add two numbers, if one is positive and the other one is negative, I get the wrong answer.

*Donovan:* I do everything right until the end of a problem. Then I get careless and make stupid mistakes—I don’t know why.

*Katie:* I need to remember that when you do minus a minus you get a plus—I kept missing that.

Students reported feeling better about their scores—"I lost a lot of points due to careless errors"—and were determined not to make the same mistakes next time. The only students who did not complete this assignment were the two students who
failed the exam—one had attended class on only three occasions and still had not picked up his exam; the other was so discouraged about his results that he “never wanted to look at that test again.”

**Researcher-Teacher Reflections**

Students were beginning to see the importance of identifying main ideas from lectures and the text. We spent most of the week discussing test preparation strategies (TST from the LASSI), and many of these strategies involved selecting main ideas (SMI from the LASSI). In my field journal, I wrote:

> Things are looking good so far. The exam grades could have been better, but the students are learning from their mistakes… I’m glad to see that they are using their phone lists and working together…I need to emphasize the importance of continuing to do so next quarter…Five students missed class the day after the exam—that drives me crazy—the idea that ‘they worked so hard, they deserved a day off.’ I need to remind the class how much they miss when they miss a class meeting!

I see that another of my implicit theories has been made explicit through this journal entry.

**Week 4**

The remainder of the quarter was devoted primarily to supporting students’ use of productive learning strategies—although new strategies continued to be introduced. During the fourth week of the quarter lectures were still modeled after the notetaking template, and I continued to emphasize big picture ideas. Students were also encouraged to read sections in their textbooks prior to the lectures and to discuss the benefits of doing so.
Course Content for Week 4

The course content for the fourth week of the quarter focused on graphing. The specific topics covered included: the rectangular coordinate system, graphing linear equations, intercepts, and slopes. The section in the text on the rectangular coordinate system was selected as a “reading” section. No lecture was presented. Students were instructed to read the text at home, attempt the homework, and bring their specific questions and/or comments to class. One of the most interesting comments was, “It doesn’t really seem like we need you [the instructor] if we just read the book—I mean it’s not that hard.”

Embedded Strategy Instruction Emphasized during Week 4

As is everything done in a mathematics class, strategy instruction/use/support was also cumulative. In addition to supporting the use of previously discussed strategies, students were introduced to the notion of goal setting during the fourth week of the quarter (Figure 20).

<table>
<thead>
<tr>
<th>Week 4</th>
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<tbody>
<tr>
<td>Journal Writing Assignment .................. Study Session Goals</td>
</tr>
<tr>
<td>Class Discussion ..................................... Useful Goals</td>
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</tbody>
</table>

Figure 20: Summary of learning strategy component of course for Week 4
Students were asked to record their study efforts for the three-week period between Exam 1 and Exam 2. Each student was instructed to record the amount of time she/he spent studying during each session; his/her goals for the session; and her/his rating of each study session (1-10). Study session goal sheets (logs), modeled after Dr. Weinstein’s study session goal sheets, were distributed to the students (see Appendix B).

**Recording Study Session Goals**

This assignment had multiple purposes. First, pilot data indicate that developmental mathematics students often overestimate the amount of time they spend studying mathematics. A student may, for example, worry about an upcoming exam for an entire day, study for only 30 minutes, and feel as though he/she has spent an entire day *studying* mathematics. Additionally, that 30-minute study session may have seemed like two hours. Recording actual study efforts (on the study session goal sheets) would provide more accurate feedback to the student with respect to her/his study efforts.

The *goal* component of the log was intended to provide direction and focus during study sessions. Students would be asked to decide—in advance of the study session—their specific (proximal) goals for the session and the amount of time they intended to allot to the session. The actual time spent studying would also be recorded.

Goal setting requires both forethought and specificity. Students often need instruction in this area—as I discovered during the piloting of this activity.
Instruction was delivered in the form of a whole-class discussion with the aid of overhead transparencies.

**Learning to Establish Useful Goals**

I began the class discussion by introducing a set of guidelines for constructing useful goals.

1. State your goal. Be Specific.

2. How will you know that your goal has been met? What evidence will support this? (If you are unable to specifically answer these questions, then go back to #1 and revise your goal.)

3. Is this goal attainable? Is it realistic? (If not, then go back to #1 and revise your goal.)

4. When will you start working toward this goal?

5. When will you stop to evaluate your progress?

After these guidelines were established, I showed the students samples of student goals from previous quarters and asked them to discuss the merits of these goals. I asked, “Are any/all/some of these goals useful goals?”

*I want to ace this class.*

*I want to learn how to use my calculator more effectively.*

*For the next two weeks I want to spend 30 minutes/day reviewing math.*

*I want to study hard and get a great grade as a result.*

*For the entire quarter I want to attend every class and turn in every assignment.*
Kelly: This is harder than I thought. You can’t just say you’re gonna do something. You have to think about how you’re gonna do it, where, when, everything!

Jake: I just like to let things happen. It’s like I work hard and all but I’m not going to beat myself up if I don’t get all “A”s.

Lisa: This is like in track. When I was a runner in high school we had to set goals and stuff and it really worked.

Estelle: What if we don’t need to spend a lot of time studying, I mean, not that I know all this, but doing the homework is usually enough for me. So that means I won’t have anything on those sheets?

Instructor: Anything you do with respect to this class—homework, study groups, tutoring labs, exam corrections, anything counts as a “study session”—record everything.

The students broke up into small groups to discuss and revise the five goals I had shown on the overhead. They also talked about their own goals with respect to the course.

**Researcher-Teacher Reflections**

By the fourth week of class, students were becoming more and more comfortable using their textbooks as resources—perhaps some were becoming *too* comfortable. I certainly did not want the students to view their texts as a replacement for regular class attendance.

Whereas attendance had been almost perfect for the first three weeks, the class was now averaging about 17 students per day (2 absences). Only one individual missed class excessively—the others seemed to rotate their days off. On the day that a student returned to class after missing a lecture, I would inquire, “Do you have any questions from your reading of section 2.3? (or whatever section they
missed). This question carried with it the assumption that the student had read the material that was covered on the day that they missed. I know that most of the students had read their texts (based on their questions and comments), and that the ones who had not read, understood that they should have done so.

I talked to Lenora, Estelle, and Janice at the end of the week about their current anxiety levels with respect to the course—these three students had identified ANX (on the LASSI) as their area of concentration. Lenora and Estelle said that they felt much better after taking the first exam—“Now we know what to expect.” Janice was convinced that she was just a nervous person and nothing would help—she worried about all her classes. Estelle offered advise to Janice: “If you just go to class all the time and do all your homework then you don’t have to be worried, because I know for me if I start to miss classes and blow off the homework then I’ll get all stressed out about it.”

Week 5

This week was the halfway point for the quarter. Students were beginning to register for their winter quarter courses and dream of Thanksgiving break. I brought a copy of the master schedule of classes with me to the developmental mathematics course and encouraged students to sign up for their subsequent mathematics courses with small groups of their peers. Four pairs of students managed to arrange their schedules to do just that.
Course Content for Week 5

Exponents and polynomials were the focus for the fifth week of classes. Lectures addressed the following topics: properties of exponents; adding and subtracting polynomials; multiplying polynomials; and special products. Developmental mathematics students find these topics particularly difficult because they are quite abstract and require precise manipulation. Jarod—the upperclassman who offered advice at the beginning of the quarter—commented, “See, I told you [referring to his classmates] it would a lot harder.”

Embedded Strategy Instruction Emphasized during Week 5

Once again, strategy support was my primary focus for the week. Students were encouraged to continue to self-reflect and self-evaluate (Figure 21). Lectures, however, began to reflect a more traditional mathematical style so that the students would assume most of the responsibility for the structure and utility of their notes. I was beginning to pull back—to relinquish both responsibility and control.

<table>
<thead>
<tr>
<th>Week 5</th>
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<tbody>
<tr>
<td>Journal Writing Assignment .................. Study Session Goals</td>
</tr>
<tr>
<td>Journal Writing Assignment .................. Preparation for Exam #2</td>
</tr>
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Figure 21: Summary of learning strategy component of course for Week 5
Study Session Goals

The students continued recording their study session activities and goals. The Study Session Goal Sheets were discussed in small groups during one of the class meetings. Students offered their fellow classmates recommendations and support.

Preparation for Exam 2

The 19 developmental mathematics students were asked to consider their exam preparation strategies (one week prior to the second examination). The following prompts were offered:

- What are you currently doing to prepare for the exam?
- What did you do in preparation for Exam 1 that you plan to do again?
- What did you do in preparation for Exam 1 that you do not plan to do again?
- How do you plan to spend your time preparing for Exam 2?
- What is your grade goal for Exam 2?

Instructional feedback was offered on the students’ journal entries. This feedback included both support and advice.

Preparation strategies. Seventeen of the 19 students said that they planned to complete all the homework assignments and take the practice test in preparation for Exam 2. Shawn—the non-attendee—reported that he planned to “go to class more” because that’s where he went wrong with Exam 1. Kelly reported that she
was “going to study harder and longer than just the night before.” Her plan of action was to do a little math every night.

**Poor strategies.** Students seemed to recognize where they went wrong in their preparation for Exam 1. Here a few of the things that the students said they did NOT plan to do again:

*Study only the night before* (Kelly)

*Put off studying* (Johnny)

*Cram!!!* (Janice)

*Not study before the test and not know where to go take the test* (Donovan)

*Wait until the last minute to review* (Tad)

*Skip some of the homework* (Estelle)

Most of the students had responded with a “do more” solution strategy—study more, attend class more often, do more homework problems. I, of course, did not want to discourage this approach, but I did want to know that the students were directing their efforts (studying productively).

**Class discussion.** After presenting a summary of the students’ journal responses to the entire class, I posed the following questions:

Question 1: How do you know what you *know* (or don’t *know*)?

Question 2: How do you know *what* you should be doing more of?

Students began to discuss how they monitored their understanding and decided what they needed to continue to review or study. Amy said that she used notecards to help her study. She would write a specific math problem on one side of the card
and solve the problem on the other. Then she would mix the cards up and see if she could still do the problems when they were out of order. She explained that this was helpful for her because tests are usually “out of order.” She said she would then focus on the cards that gave her the most trouble.

I asked Amy how she decided what problems to write on the cards. She said that she selected a few sample problems from each section in the book. She also included problems from the sample test. Donovan suggested that, “Maybe if you don’t have time to make notecards, you could just cut up the practice test and do those problems out of order.”

**Researcher-Teacher Reflections**

At this point in the quarter, my role as facilitator during classroom discussions was minimal. I would pose a question and the students would take it from there. They were comfortable discussing course-related study tactics and strategies, and typically offered good sound advice. *Knowing* and *doing* however are two different things.

For example, student quiz averages were beginning to decline. Recall that the 19 students had elected to take open-notebook quizzes. If a student completed his/her homework assignment, checked the answers with the solutions in the back of the book, and brought the assignment to class, then the student would be guaranteed a perfect score. All 19 students *knew* what they needed to do to prepare for the quizzes.
Of the 18 students who took the quiz during the fifth week of the quarter, only 10 students received perfect scores. One student scored 70%, 2 students scored 60%, and five students scored 50%. Tad—who scored only 50% on the quiz—explained that he only had time to do half of the homework because he had a big psychology midterm to study for. I talked to four other students who scored less than 100% on the quiz and heard similar time-management related excuses.

Sometimes we, as instructors, forget that a student’s time and attention is often divided among many subject areas. Tad pointed out that he had perfect quiz scores up to this point, and he knew that one low quiz grade in this math class would not hurt his average. He made a conscious decision to study psychology instead of mathematics.

I realized that I had been assuming that those students who did not earn perfect scores on the quizzes were just “blowing off the homework.” Another of my implicit theories had surfaced and this theory was in need of revision.

**Week 6**

Most of the sixth week of the quarter was spent reviewing for, taking, and analyzing the second major exam. A minimal amount of new content, however, was introduced at the end of the week (division of polynomials).

**Embedded Strategy Instruction Emphasized during Week 6**

Strategy instruction during the sixth week of the quarter focused on students’ study efforts (as recorded on their study session goal sheets) and on examination results and analyses (the exam correction/analysis assignment). Additionally, an
investigative project was assigned at the end of the week (after the administration of Exam 2). A summary of strategy-related activities is found in Figure 22.

<table>
<thead>
<tr>
<th>Week 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Journal Writing Assignment</td>
</tr>
<tr>
<td>Homework</td>
</tr>
<tr>
<td>Project</td>
</tr>
</tbody>
</table>

Figure 22: Summary of learning strategy component of course for Week 6

**Preparing for Exam 2**

The 19 developmental mathematics students decided that the in-class review for the second major exam should focus on big picture ideas from the text. They also wanted to discuss the sample tests they had purchased. This review was very similar in structure to the first examination review. Students, however, seemed more apprehensive about the material to be covered--“*there are so many places to mess up.*”

**Study Session Goals**

The 19 developmental mathematics students were asked to submit their study session goal sheets on the evening of the second exam. This exercise had forced the students to focus on their actions with respect to the course for the previous three
week period. An analysis of the goal sheets revealed that students often \textit{planned} to spend more time engaged in study than was actually the case. According to the students' self-report data, an average of only 3.5 hours per week was spent on study activities related to developmental mathematics.

\textbf{Instructional phases.} According to Zimmerman and Paulsen (1995), the teaching of self-monitoring skills (the focus of the study session goal sheet activity) occurs in four phases: (1) baseline self-monitoring; (2) structured self-monitoring; (3) independent self-monitoring; and (4) self-regulated self-monitoring. The students' recorded responses on the study session goal sheets were representative of the first and second phases of self-monitoring. Recorded goals and behaviors are considered baseline self-monitoring activities. Session ratings (which are self-evaluative judgments) coupled with my written feedback are considered to be structured self-monitoring activities. Students move into independent self-monitoring when they begin to create their own protocols for monitoring their academic activities. The ultimate goal—self-regulated self-monitoring—is accomplished when students monitor their academic progress without instructional guidance or support.

\textbf{Whole-class discussion.} The day after the exam, I asked my students to help me design a new study session goal sheet that would better meet their needs. Students came up with a variety of suggestions.

\textit{Rachel:} It would be nice to have a checklist for things like looking at your notes, reading the book, doing the homework,...you know like, suggestions.
Janice: I think it would be easier if everyone just made their own paper because we all do different things, we could personalize it.

Instructor: Let’s do that. Why don’t you all create your own templates for recording your goals and efforts?

The original study session goal sheets were made available to all students who requested copies. Lenora, Mark, Estelle, and Lisa continued to use the original forms for the remainder of the quarter. Janice constructed her own form.

Examination Results and Analyses

The second major examination consisted of 25 questions—seven multiple choice and 18 free response (the typical examination format). The problems on the exam were distributed relatively evenly among the content areas discussed in class.

Results. The median score that was reported by the mathematics department for 381 of the 465 students who took the second exam was 80% (data from two instructors were unavailable). The students enrolled in the strategy embedded developmental mathematics course had a median score of 77%. A detailed comparison of the strategy-embedded group with the remaining population can be found in Figure 23. These statistics reveal that the percentages of students who passed the exam with a grade of C or better were approximately the same (73%) among both groups (see Figure 24 for a bar graph comparison of letter grades).

All but four of the students enrolled in the strategy-embedded developmental mathematics course earned scores equal to or better than their previous exam
![Table: Exam 2 Grades](image)

**Figure 23: Descriptive statistics of Exam 2 grades**

scores—although these types of comparisons are not necessarily meaningful since the content of the two exams was extremely dissimilar. I talked to the four students who earned letter grades on Exam 2 that were lower than their letter grades on Exam 1.

Jarod had no idea what he was doing wrong. He earned a C on Exam 1 and an E on Exam 2. He reported that he completed approximately 70% of the homework assignments and “should have had about 70% on this last midterm.”

Mary—whose grade dropped from a B to a C—claimed that “when [she] was doing her homework [she] was relaxed but during the midterm [she] was very nervous.” She believed that she made careless errors on the exam—I agreed.
Figure 24: Comparison of grades on Exam 2

- □ students who did NOT receive strategy instruction (n = 362)
- ■ students enrolled in strategy-embedded course (n = 19)
Kelly—whose grade dropped from a C to a D—confessed that she had spent too much time studying for her psychology midterm and not enough time studying math. Like Mary, she felt that she had made too many careless mistakes.

Vernon—whose grade dropped from a B to a C—felt that he should have spent more time “figuring out what it was that [he] didn’t understand, instead of just doing the homework and being glad it was done.” He said that when he got to the problems on the test that dealt with graphing lines based on their slopes, he remembered that he had experienced difficulties with those types of problems when he had done the homework for that section.

Exam correction and analysis assignment. Once again the 19 developmental mathematics students enrolled in the strategy-embedded course were required to correct their exams and analyze their mistakes. Students were encouraged to integrate this assignment with the Investigating Available Resources project (described below). With respect to the analysis portion of this assignment, the students reported that they (a) made the same mistakes over and over again throughout the exam, and (b) made too many careless errors.

Investigating Available Resources

There are many resources available to assist students enrolled in mathematics courses at the Ohio State University (for example: tutoring labs, extended instruction sessions, minority student services, dormitory tutoring facilities, copies of old exams, and computer labs). Most of these resources are made available at no cost to the student, and some of these resources are seriously underused (the
mathematics tutoring facility, for example). Perhaps students would be more likely to take advantage of these resources if they took the time to locate and test-drive these services.

The 19 developmental mathematics students, as part of the strategy-embedded course, were required to experience at least two of the available resources. Students were given two weeks (Week 7 and Week 8) to complete this assignment. They were instructed to summarize their experiences on paper and to be prepared to share their impressions with the entire class. Each student was given a map of the campus. The students and I developed a partial list of resource options. Students were not, however, limited to these resources.

**Researcher-Teacher Reflections**

Of course I would have liked to see higher exam scores, but that did not happen. The grades on the second midterm were not bad, but they could have been better. I did, however, observe something atypical of this population—something I considered a **good thing**. Students were taking responsibility for their own actions and the results associated with these actions AND they understood that they had the power to change their current states. Not one student—in oral conversation or written communication with me—blamed the test (“tricky” problems) or the test writer for his/her mistakes or results. All the students (except Jarod) understood why they did well or why they “messed up” on the exam. The students seemed to know what they should have done and/or should continue to do.
Choice was a key theme noted in my field journal regarding the students' explanations of their examination results. Students had elected to do homework or not to do homework; to study for both psychology and mathematics or to study for only one subject; to review a little every night or to study all night the evening before the exam. The class as a whole had an "It's not you, it's me" attitude toward their results. The "it's me" part meant:

- I studied hard, got a good grade, and I deserved it! or
- I know what I should have done, I didn't do it, and my grade reflects that.

The "it's me" part did NOT, however, mean, "I'm stupid, I'll never get this, so why do I even bother?" Students were developing healthy self-efficacy perceptions.

As a way of providing other options to assist students in taking control of their learning, I created the resource investigation project. Some readers are probably wondering why I waited until so late in the quarter to begin this project. I had several reasons for waiting. To begin with, the students had unofficially been exploring (using) support resources all quarter long—textbooks, study groups, instructor's office hours, and the class telephone directory. I was not actually withholding support by postponing this activity, but rather I was distributing the introduction of resources throughout the quarter.

Before the students began test-driving various tutoring facilities, I wanted to help them improve their self-assessment and questioning skills. I knew they would not be able to get the tutoring assistance they really needed unless they knew how to
ask for it. The first six weeks of the quarter had been devoted to enhancing their skills in this area.

Several times during my lectures, I would stop to ask if anyone had any questions. At the beginning of the quarter, the reply I most often received was, “I don’t get what you did in that example.” Mathematics instructors often respond to this statement (note that it is NOT a question) by repeating their explanations—which may or may not be useful to the student. When my students said, “I don’t get what you did in that example,” I responded with, “Can you rephrase that into a specific question?” I would not answer until they did just that—even if I knew what they were trying to ask. Articulation of needs is an important component of successful tutoring.

Week 7

The seventh week of the quarter was a short week. We had a day off—Tuesday—for Veteran’s Day and eight of my students took a “sick day” on Monday. I suspected this might happen (and it appears the course coordinator also thought this was a possibility because the content material scheduled to be covered on Monday was a repeat of the previous Friday’s topic).

Course Content for Week 7

The content focus for the last four weeks of the quarter was factoring. During the seventh week of the term students learned about greatest common factors, factoring by grouping, and trinomial factorizations.
Embedded Strategy Instruction Emphasized during Week 7

Students were reminded about the exploring available resources project that had been assigned during the previous week. They were encouraged to share their experiences with the entire class as they occurred. Lisa—a student athlete—talked about the tutoring options available through the athletic department. She met with a private math tutor twice a week. Lisa got permission from her tutor (whom she describes as “a really nice guy who knows what he’s talking about”) to invite others from the class to attend the sessions with her. Two of the students from the class (Katie and Janice) agreed to “give it a try.”

One new project was announced this week, and another journal was assigned (Figure 25). Instruction continued to encourage and support students’ use of directed learning strategies. Transfer of strategy use, however, became the main focus for the remainder of the quarter.

<table>
<thead>
<tr>
<th>Week 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project ....................... Exploring Available Resources (continued)</td>
</tr>
<tr>
<td>Project ....................... Investigating the Next Mathematics Course</td>
</tr>
<tr>
<td>Journal Writing Assignment ................. Exam Scores Analysis</td>
</tr>
</tbody>
</table>

Figure 25: Summary of learning strategy component of course for Week 7
Investigating the Next Mathematics Course

Students were asked to consider visiting a mathematics lecture for the course they would be attending during the following term. This project was optional but highly recommended because some of the subsequent mathematics courses at the Ohio State University are structured very differently from the developmental mathematics courses.

In a developmental mathematics course at Ohio State: (a) class size is limited (typically less than 25 students per class); (b) direct contact with the instructor is maximized (daily class meetings); and (c) attendance is emphasized (credit is awarded for attendance). In most of the subsequent college-level mathematics courses: (a) instruction is presented in a large lecture hall (100 to 300 students per class); (b) a lecture-recitation format is used (students attend lecture three days per week—MWF—and recitation the other two days); (c) recitations are typically conducted by senior (undergraduate) mathematics majors; and (d) attendance is not emphasized.

The 19 developmental mathematics students had second-hand knowledge of this information—I had been discussing these differences all quarter long. I still believed that they would benefit from the first-hand experience of visiting a college algebra lecture. I compiled a list of the current college algebra meeting times and places and gave each of the students a copy of these data. They were told that their observations would be welcomed and that there was a good chance (probably 99.99%) that no one would even notice that they were there.
Jake responded to this assignment with, “Cool, you mean we can really do that?” I surveyed the class and discovered that nine of the 19 students had enrolled in a college algebra course (during early registration) scheduled to begin next quarter. All nine of these students eventually visited a college algebra lecture. Donovan decided to write about his experience:

In doing this assignment I have learned that I have what it takes to accomplish [college algebra] at Ohio State. Through attending the lecture and looking over the sample test packet for the class I feel very comfortable as far as taking it during winter quarter. As I sat in the lecture which was held at Haggerty Hall I became familiar with the material that was being covered. Since I had taken an Introduction to College Mathematics course during my senior year in high school, I feel like I have the ability to accomplish mathematics at the college level. As far as attending this class [at Haggerty Hall] it has got me a little excited for my next class coming up. I know that it isn’t going to be all easy but it seems as if it is material I am familiar with.

I really appreciate the assignment that was given us. I think that it gives me an idea based on what is going to be covered in the next math course that I will be taking. I have to say that I hadn’t really thought about taking the opportunity to go and visit some of the classes that I was going to take the next quarter but I am glad that we had that opportunity and I am planning to implement the same process as I continue my college education.

Other students commented on how their next courses were going to be very different from our class because “more seems to be up to you.” Kelly said that she realized that she would need to sit at the front of the class (in order to stay focused) and develop faster notetaking skills. Johnny found it difficult to understand the lecturer in the class that he attended because he was “foreign and didn’t speak very good English.” He thought it would be important to know who the lecturer was going to be before enrolling in a course.
Students also commented that they really did need to know (and remember) the content that was being covered in the developmental mathematics course. According to Tad, “the material that we are covering in [the developmental mathematics course] will translate directly to [college algebra].” Tad also asserted that, for him, “the intimidation factor was no longer an issue.”

**Relationship Between Exam 2 Scores and Students’ Actions**

I had observed during Week 6 that my students, for the most part, were taking responsibility for their own performances on the second exam. I was interested in learning more about their perceptions and attributions so I asked them to complete the following journal assignment (Figure 26).

---

**Journal**

Give your best rough estimate for each of the following:

1. I attend math class________percent of the time.
2. I complete my homework assignments on the day they are assigned________ percent of the time.
3. I eventually complete________percent of my homework.
4. I check my work with the answers in the back of the book________percent of the time.
5. I would classify________percent of the homework as very difficult.
6. When I am having trouble, I ask for help________percent of the time.
7. My quiz average is approximately________.

Look at your score on Exam 2. Is there any relationship between your exam score and the percentages above? Explain.

---

Figure 26: Student journal prompts
Student journal data (particularly responses to the last prompt) supported my belief that those students who were "doing well" (based on their own perceptions) knew what they had done to promote their own success. While those students who were "not doing well" (again, based on their own perceptions) knew what they ought to be doing. It is interesting to note, from a mathematical perspective, that three students reported 98% to 99% attendance rates in mathematics class because they had only missed class once or twice. In my quest for information, I never know what I'm going to get! A short lesson on percentages was presented at the end of the week.

Researcher-Teacher Reflections

As students visited college algebra lectures and reported their impressions to the class, we began to talk more and more about the students' plans of action for the next quarter. Is it important to attend class? Why? Will you schedule a specific time to do your homework? Where will you go for help? How will you prepare for exams? What are your goals? How will you organize your notes? Will you find a study group? How?

Week 8

During the eighth week of the quarter, content instruction continued to focus on factoring. Binomial factorization techniques were introduced. Because the third exam was scheduled for the Monday of the following week, the latter part of Week 8 was devoted to review (Figure 27).
Embedded Strategy Instruction Emphasized during Week 8

Instead of leading a review session for Exam 3, I asked the students to construct their own review. The students, working in small groups (3 to 4 per group) were asked to predict examination questions. I offered no assistance. After about 20 minutes, each group talked about what they thought would be on the exam, why they thought it would be on the exam, and how they made their determinations.

Their predictions were extremely accurate. Students had used their class notes, the textbook, and copies of old examinations to complete this assignment. We used these student-constructed sample problems to guide our review on the following day. After our review was complete, I asked the students if they would have “done this on their own.”

Jake: I do this for all my classes—create sample problems and stuff—but it is easier to figure out what’s gonna be on these [math] tests.

Lisa: I think I would think of it now.

Rachel: They even have practice tests for sale for college algebra. I found that out when I went to the dorm tutor room [as part of the resource investigation project]—someone showed me a copy.
I asked the class if anyone else wanted to share his/her experiences with respect to the resource investigation project. Four students (in addition to Rachei) had discovered that for $1.03 they could (legally) purchase copies of old exams for college algebra—so they did. These students were amazed to find that copies of old exams were available for a variety of courses (Chemistry, Physics, Psychology, etc.) and encouraged everyone to investigate this resource.

Mark talked about how he had started going to the Mathematics-Statistics Learning Center (MSLC) on Tuesdays and Thursdays and was “practically getting free private tutoring” because he was usually the only student in the lab at that time. Estelle discovered that she could get a free private tutor through minority student services. (I was unaware of this possibility.)

I asked the students if any of these resources were only available to students enrolled in developmental courses. Mark said that the MSLC had rooms set up for all the different math courses. Estelle said she could get a free tutor for any class.

**Researcher-Teacher Reflections**

I could feel my role as a “strategy instructor” diminishing as the quarter progressed. The students were gaining control and making their own decisions—even if they weren’t the decisions I would have liked for them to make. They were now aware of a variety of resources and mathematics-specific learning strategies, and were in an environment where they could continue to practice these strategies.

I had decided to begin presenting lectures in a style that would more closely model the type of instruction delivered in college-level mathematics courses. I
thought I was doing just that when a colleague pointed out otherwise. This person, who observed one of my lectures, noted that I had emphasized the main ideas of the topic under consideration; connected the lesson to previous lessons on the same topic; and told the students where in the textbook to find the material that I had covered. Additionally, my organized presentation style and large, legible handwriting were noted. I was told that I was in no way modeling “typical instruction.” Similar comments were made by a second observer.

Week 9

The week of Thanksgiving break had finally arrived. Exam 3 took place on Monday. The following two days were devoted to instruction on solving quadratic equations by factoring (as was the Monday after the Thanksgiving holiday). Only seven students were able to attend class on the Wednesday before Thanksgiving. We were all ready for some time off.

<table>
<thead>
<tr>
<th>Week 9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recommendation............... Exam #3 Analysis and Corrections</td>
</tr>
</tbody>
</table>

Figure 28: Summary of learning strategy component of course for Week 9

**Embedded Strategy Instruction Emphasized during Week 9**

Students were not *required* to analyze or correct the third exam. This was not a homework assignment as it had previously been. At this point, most of the
students (at least 13) realized the benefits of this learning strategy and elected to correct and analyze their exams on their own. I volunteered to review their corrections.

The median score on Exam 3 reported by the mathematics department for the 465 students who took the exam was 70% (includes all sections). The students enrolled in the strategy-embedded developmental mathematics course had a median score of 74%. A more detailed comparison can be found in Figures 29 and 30.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Number of students</th>
<th>Percentages</th>
<th>Number of students</th>
<th>Percentages</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>50</td>
<td>11.21%</td>
<td>1</td>
<td>5.26%</td>
</tr>
<tr>
<td>B</td>
<td>93</td>
<td>20.85%</td>
<td>5</td>
<td>26.32%</td>
</tr>
<tr>
<td>C</td>
<td>93</td>
<td>20.85%</td>
<td>6</td>
<td>31.58%</td>
</tr>
<tr>
<td>D</td>
<td>76</td>
<td>17.04%</td>
<td>2</td>
<td>10.52%</td>
</tr>
<tr>
<td>E</td>
<td>134</td>
<td>30.05%</td>
<td>5</td>
<td>26.32%</td>
</tr>
</tbody>
</table>

Figure 29: Descriptive statistics of Exam 3 grades

I talked to the five students (individually) who had failed the exam. Lenora said that she had decided to take the class over again during the winter quarter and to evoke "freshman forgiveness" (the option to retake a course, replace the course grade, and have the original grade erased from her records). This option is only
Figure 30: Comparison of grades on Exam 3
extended to freshmen with less than 45 quarter-credit hours. Lenora continued to attend class and take examinations because she thought it would help her for the next time she took the course. She admitted, however, that she had to concentrate her efforts on English and Psychology because those grades were going to count. Lenora realized that a big part of her problem in the developmental mathematics class stemmed from her high school mathematics background. She had talked about her inadequate foundation in her mathematics autobiography at the beginning of the quarter.

Mark was not sure what he was doing wrong or why he failed the exam. He had been going to the tutoring lab every Tuesday and Thursday, and thought he was putting enough effort into the course. The two of us reviewed his study session goal sheets—which he maintained throughout the quarter—and agreed that the amount of time he was devoting to the class was adequate. We decided to meet the Monday after Thanksgiving to discuss better options for monitoring his understanding as well as self-testing methods. Mark had indicated TST (testing strategies) on the LASSI as his area of concentration earlier in the term.

Vernon and Janice knew exactly why they had failed the third exam. Both were working more than 40 hours each week and trying to maintain a full course schedule. They simply did not have the time to prepare for the test.

Shawn also knew why he had scored a 39% on Exam 3. According to Shawn, “I’ve probably only come to class about 39% of the time.” My records indicated that he had attended 42% of the time.
Researcher-Teacher Reflections

According to Zimmerman (1998), “Skillful self-regulators attribute negatively evaluated outcomes mainly to strategy use, learning method, or insufficient practice whereas naïve self-regulators tend to attribute them to ability limitations” (p. 9). My discussions with Lenora, Mark, Janice, Vernon, and Shawn revealed that these students—the lowest achievers in the class on Exam 3—were not attributing their outcomes to ability limitations. This is not to say that these five students were necessarily “skillful self-regulators.” It does, however, suggest that even the lowest achievers were developing characteristics of skillful self-regulators.

Vernon commented that he was glad we discussed his performance on Exam 3 because, “usually if you flunk, the teacher just thinks you don’t care or you are just stupid or something, and I wanted you to know I cared about this stuff and that I could do it.” I contemplated what Vernon had said. I wondered what other instructors would assume about students who were failing developmental mathematics so I stopped a colleague in the hall and asked his opinion. He said that anyone who was failing these exams probably didn’t belong in college. I can’t (won’t) assume this is the general sentiment among mathematics instructors, but I was alarmed by his response.

On a more positive note, I was pleased to discover that although exam corrections were not required for Exam 3, students were continuing to engage in various aspects of this activity. “For academic learning techniques to become fully self-regulated, students need opportunities to rehearse and develop them on their
own” (Zimmerman, 1998, p. 11, emphasis added). I wanted my students to engage in strategy use because they believed it to be useful, not because I required them to do so.

Week 10

During the last week of the term, one new section of mathematical content was introduced—problem solving using quadratic equations. Three of the five class meetings during the tenth week of the quarter were spent reviewing for the comprehensive final exam scheduled for the following Monday.

Embedded Strategy Instruction Emphasized during Week 10

Strategy instruction during Week 10 emphasized the transfer of strategy use to students’ next mathematics courses (Figure 31).

<table>
<thead>
<tr>
<th>Week 10</th>
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<tbody>
<tr>
<td>Self-Evaluation Survey</td>
</tr>
<tr>
<td>Class Discussion</td>
</tr>
<tr>
<td>Journal Writing Assignment</td>
</tr>
</tbody>
</table>

Figure 31: Summary of learning strategy component of course for Week 10

Self-Evaluation Survey

Students again completed the same self-evaluation survey (11-item Likert-type scale) that they had completed on the first day of the quarter. A summary of
their responses can be found in Figure 32. I shared these summary data with the entire group of student respondents. During a whole-class discussion, students were asked to comment on any changes in their responses from the first day of quarter to the last. Recall that the following eleven statements were included in the survey:

1. I usually have a difficult time understanding mathematics.
2. I am confident in my ability to perform well on a mathematics test.
3. I know how to study mathematics.
4. I am good at mathematics.
5. I usually ask questions when I do not understand.
6. I know where to go for help.
7. When a mathematics problem is difficult I can learn how to do it.
8. I am easily discouraged when working on a mathematics problem.
9. Learning mathematics is important to me.
10. Getting good grades is important to me.
11. My success in mathematics depends heavily on the instructor.

Responses to these statements ranged from Strongly Disagree/Disagree (0, 1, 2, 3) to Agree/Strongly Agree (7, 8, 9, 10). Responses in the 4, 5, or 6 range were considered Neutral.

This activity was intended to foster student self-reflection. As a result of reviewing their first-day responses, students might better recall how they felt and
Figure 32: Comparison of Beginning and End of Quarter Survey Responses
what they believed at the beginning of the quarter. This would allow them to better assess their own progress and growth.

**Statement 1.** At the beginning of the quarter more than half of the students in the class agreed with the statement: *I usually have a difficult time understanding math.* By the end of the term, only four students agreed with this statement. Kelly, who agreed with the statement at the beginning of the quarter and disagreed at the end, explained that she had gained confidence as the quarter progressed because of the learning strategy instruction. Mark, who still agreed with the statement at the end of the quarter, said that understanding was (and probably always would be) difficult for him, but this just meant that he would need to spend more time studying than most.

**Statement 2.** While most students were not confident in their ability to perform well on a mathematics test at the beginning of the quarter, by the end of the quarter no one reported disagreeing with the statement: *I am confident in my ability to perform well on a mathematics test.* Most students entered neutral responses. Tad explained that although he knows what it takes to do well on an exam he doesn’t always have the time to do everything that needs to be done. For this reason he responded neutrally to this statement.

**Statement 3.** At the beginning of the quarter more than half of the students strongly disagreed with the statement: *I know how to study mathematics.* By the end of the quarter, no one disagreed with this statement. Students talked about
knowing what to do, but not always doing what they believed they should be doing. Time management issues were mentioned by several students during the class discussion.

**Statement 4.** When the quarter began, most students believed that they were not good at mathematics. By the end of the quarter, students' sentiments had changed to either “I guess I’m okay at this stuff”—Rachel, or “I can’t believe I'm actually saying this, but I think I am good at math”—Johnny.

**Statement 5.** Students reported that they asked questions more often now than they did at the beginning of the term because it was easier to do so. They could use the telephone list to call a classmate or they could go to the tutoring labs. They reported that it was less frustrating to ask for help than to try to figure everything out on their own. I took this opportunity to again talk to the students about how they would build a communication network in their next mathematics courses.

**Statement 6.** It was not surprising that most students reported that they knew where to go for help by the end of the quarter. The resource investigation project was a big success. I asked the students to continue to think about what resources they would use during the next term.

**Statement 7.** At the beginning of the quarter, only five students agreed with the statement: When a mathematics problem is difficult I can learn how to do it. By the end of the term, 14 students reported agreeing with this statement, and
no on reported disagreeing with the statement. Students' judgments about their abilities to learn mathematics (self-efficacy beliefs) had improved tremendously as the quarter progressed.

**Statement 8.** At the end of the quarter, most students reported that they were still *easily discouraged when working on a mathematics problem.* When I asked the students to explain why they felt this way, five students referred to the specific content we had covered the day before they completed the survey—solving word problems using quadratic equations. They reported feeling frustrated and discouraged as they worked through the homework set on this section.

**Statement 9.** Students felt at the beginning of the term and continued to feel at the end of the quarter that *learning mathematics was important to them.* I asked them why it was important. Here are some of their responses:

*Johnny:* I need to take a lot of math for my degree, so learning this stuff is just the beginning—it's real important.

*Rachel:* Math is something everybody needs to know.

*Mary:* You feel stupid if you can't do math.

**Statement 10.** Grades are very important to college students. Getting good grades was important at the beginning of the term and continued to be important at the end of the term.

**Statement 11.** At the beginning of the quarter 12 students felt that their *success in mathematics was heavily dependent on the instructor.* By the end of the quarter, most students responded neutrally to this statement. Students were initially
hesitant to discuss their responses in class because, as Donovan put it, “it’s not like we don’t like you and all, but we really have to do a lot of this on our own.”

**Summary.** Overall, I was encouraged by the students’ responses and our whole-class discussion. I tried to engage the students in conversations about strategy use in their upcoming mathematics courses as often as possible. I also asked them to consider their specific goals for the winter 1998 quarter.

**Next Quarter Goals**

Students were asked to develop a set of goals with respect to mathematics for the following quarter. They were asked to write about their attendance goals, their learning or performance goals; and their plans of action for achieving those goals.

**Attendance.** Everyone said that attendance was important and they would strive to go to class 100% of the time. Katie said that she knows that she is bound to miss a class or two so she will need a backup plan. She hopes to find someone in her lecture to exchange phone numbers with in case she misses a class. Vernon said that he plans to work less hours next quarter so that his attendance will be more regular. Candie confessed that:

I learned that I need to attend every day. If I miss one day, I miss a lot more information than I realized. Of course, I learned the hard way—attendance makes a difference in the final grade sometimes.

Tad said that he planned to attend “through rain, sleet, and snow.”
Learning and performance goals. Most of the students talked about learning goals in their journals. A few students discussed grade (performance) goals for the upcoming quarter. Students’ plans of action were becoming more defined and more specific.

Tad: I plan to maintain a working knowledge of all principles as they are presented (my falling behind on our last chapter has definitely hurt me—I definitely won’t let this happen next time around.) I will make sure I stay current on all homework, attend every class humanly possible, maintain a positive attitude, and get one of those nifty graphing calculator deals with the built in games. If I need help, I will go to the tutoring lab or ask my teacher, whatever it takes.

Mark: I’m going to be very successful on all quizzes and tests. I plan to study harder and get more tutoring.

Kelly: I plan to use my [developmental] math skills to get better at [college algebra]. Then I will take the math classes for elementary teachers. I plan to study further in advance for quizzes and midterms and do all homework assignment and be prepared for class. Also, I plan to attend every lecture. I am going to find someone to study with and meet with my teacher whenever I need help.

Vernon: I am going to study more and work on understanding the steps in solving each problem. I will set my alarm early every day so I’m not late; find people who have a grasp of what I don’t know and study with them. I will also pay more attention in class and get more sleep so I can stay awake.

Candie: I’m going to maintain an A or B. I also plan to attend the math labs when I need help to learn everything better. I will do my homework when it is assigned and also review. If I need help, I’m going to make an appointment to talk to my professor.

Rachel: I’m going to spend more time studying and ask more questions. Also, I plan to make time for tutoring. I plan to receive an “A”. I’m going to do all my homework. I will go to my professor or a tutor or to math lab if I need help.
Johnny: I am going to attempt to learn and to understand everything in my class. I plan to go to sleep earlier, be more attentive and set up a better study area. I also plan to study with more of my classmates.

Kristin: I am going to understand the material by the end of every week and be able to master it. To do this I will need to attend class and do all the homework. If I get stuck, I will ask my teacher for help.

Jarod: My goal is to do better on exams. I will study more and go to the instructor, my family and my friends if I need help.

Shawn: I plan to get good grades by going to class more.

Amy: I plan to make use of the services that are offered. I’m going to get all the study guides; work on taking better notes; ask questions rather than sit and hide from embarrassment; and connect with other students to form a study group. If I need help, then I’m going to speak up (scream “Help”); ask questions; and stop crying and get assistance.

Lisa: I plan to understand every section; complete the homework each night; make sure each answer of my homework is correct with the back of the book. I’m going to do a little each night and go to the math tutors if I need help.

Donovan: I plan to focus on understanding the material which will be taught and use what I have learned in order to do well on midterms, quizzes and finals. I will attend extended instruction sessions and get a tutor from the office of minority affairs.

Estelle: I plan to do all the assignments and study hard. I will go to the tutoring sessions and talk to my instructor or a classmate if I need help.

Jake: I’m going to complete all the homework and pay attention in class. I will also plan a lot of study time. I will need to schedule time to study.
Feedback was offered on the students’ written goals: How will you accomplish___? How long will you spend engaging in _____? How will ______ help you meet your goals? Have you considered________?

Teacher-Researcher Reflections

I was going to miss this group of students. They (we) had come a long way in just 10 weeks. I was relieved to find that their dependence on me had decreased as the quarter progressed. They were becoming independent learners.

End-of-Course Data

The following pages contain summaries of (a) course attendance records from the strategy embedded developmental mathematics course (Figure 33); (b) students’ quiz averages (Figure 34); (c) students’ final examination scores (Figure 35); and (d) students’ final course grades (Figure 36). Student attendance was excellent throughout the quarter. Recall, however, that attendance did affect students’ course grades—perhaps increasing motivation to attend. Readers may be surprised to find that only nine students earned quiz averages of 90% or better given the nature of the quizzes. I saw these data as reflective of time management skills and student effort (student choice behaviors).

Students’ final exam scores and final course grades were typically identical. Sixteen of the 19 students finished the course with a grade of “C” or better. Only two students failed the course—Shawn (the student who rarely attended) and Lenora (the student who opted to repeat the course—freshman forgiveness).
Figure 33: Course Attendance
Figure 35: Grade Distribution on Developmental Mathematics Final Examination
Figure 36: Distribution of Final Course Grades
Figure 37: Comparison of grades on comprehensive final exam

Figure 38: Comparison of course grades
Students' Evaluation of Instruction

When I read classroom research reports, I find that I am always curious about the instructor. I wonder what type of classroom environment he/she fosters and what his/her students think of the instruction. In this report, I have offered numerous insights regarding my instructional style and demeanor. I have also included countless student perspectives. One final evaluation is offered.

On the day of the final examination, the 19 developmental mathematics students were given the opportunity to complete a Student Evaluation of Instruction Report (SEI). These forms consist of ten statements. The response scale is Likert-type with "5" being high and "1" being low. Responses are confidential and the university compiles these data and provides a summary report for the instructor. Highlights from this summary are found in Figure 39.

<table>
<thead>
<tr>
<th>1. Instructor well organized</th>
<th>N</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>18</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>6%</td>
<td>94%</td>
<td>4.9</td>
</tr>
<tr>
<td>2. Intellectually stimulating</td>
<td>18</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>17</td>
<td>72</td>
<td>4.6</td>
</tr>
<tr>
<td>3. Instructor interested in teaching</td>
<td>17</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>5.0</td>
</tr>
<tr>
<td>4. Encouraged independent thinking</td>
<td>18</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>5.0</td>
</tr>
<tr>
<td>5. Instructor well prepared</td>
<td>17</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>94</td>
<td>4.9</td>
</tr>
<tr>
<td>6. Instructor interested in helping students</td>
<td>18</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>5.0</td>
</tr>
<tr>
<td>7. Learned greatly from instructor</td>
<td>18</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>94</td>
<td>4.9</td>
</tr>
<tr>
<td>8. Created learning environment</td>
<td>18</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>5.0</td>
</tr>
<tr>
<td>9. Communicated subject matter clearly</td>
<td>17</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>94</td>
<td>4.9</td>
</tr>
<tr>
<td>10. Overall rating</td>
<td>18</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>5.0</td>
</tr>
</tbody>
</table>

Figure 39: Summary of student evaluation of instruction (SEI)
Students' Enrollment Choices for Winter 1998

Students had four options for mathematics class enrollment during the following quarter: (1) repeat the developmental mathematics course; (2) enroll in the second developmental mathematics course in the sequence; (3) enroll in college algebra; or (4) opt not to take a mathematics course. Two students decided to repeat the developmental mathematics course (Shawn and Lenora) during the winter quarter. Three students (Amy, Jarod, and Katie) registered for the second course in the developmental sequence (which serves as a prerequisite course for business and liberal arts majors). Twelve students registered for college algebra (Tad, Johnny, Jake, Donovan, Kelly, Mary, Rachel, Estelle, Mark, Vernon, Candie, and Lisa). Kristin and Janice did not enroll in mathematics courses during the winter 1998 term.

Summary

In this chapter I presented a week-by-week description of the strategy-embedded developmental mathematics course. I wanted to bring readers into the classroom, to allow them to get to know the students, the curriculum, and the learning environment. Much of the data presented herein were included to assist the reader in understanding this world. According to Winne (1995), “Rich, descriptive studies of long-term learning activities are needed in which newly acquired knowledge is honed and generalized through practice” (p. 181). The current chapter serves to partially fill this void in the research literature.
As I talked about this project with mathematics faculty and mathematics education faculty, I made note of the various types of questions they posed. I tried to include data related to these issues within this chapter. In providing this thick description (Patton, 1990), I am allowing the reader to draw his/her own conclusions—which may, in fact, differ from my interpretations. I believe that it is important for any qualitative inquiry to be open to this form of critique.

**Reflecting on the Course Design**

This course could not (would not) have been constructed without the professional support and influence of Dr. Claire Ellen Weinstein. Her Model of Strategic Learning provided a structure for the design of this content-specific study skills course (conceptual framework). The research literature also provided valuable information with respect to the types of strategies that can and should be taught in a mathematics classroom.

**Recommendations of Others**

My instructional style was most influenced by recommendations from Pintrich (1995) and Schoenfeld (1992). I worked throughout the quarter to develop students’ awareness with respect to their *task-specific behaviors and motivations*. As recommended by Pintrich, the LASSI was used to facilitate this awareness. In addition, a variety of researcher-created self-reflective and self-evaluative exercises were introduced.

During this 10-week instructional period, I also focused on developing *positive motivational beliefs* (self-efficacy perceptions) among the students. Data
indicate that student confidence levels did increase as the quarter progressed (survey responses, class discussions, and journal entries). Students began to believe that they were capable of learning and understanding mathematics.

As recommended by Pintrich (1995), I used every opportunity possible to model self-regulatory skills. I used “think aloud” techniques when solving mathematical problems during lectures. I also modeled specific self-regulatory skills such as notetaking and reading in the content area. These techniques were not only modeled, but students were required to use and practice these skills throughout the quarter.

Schoenfeld (1992) had recommended that faculty use whole-class discussions and questioning to facilitate the development of self-regulatory skills. These techniques were employed throughout the course. Additionally, an emphasis on big picture ideas was noted by Schoenfeld. This, too, was an integral part of my instruction.

**My Goals**

I had three specific instructional goals at the beginning of this project. I wanted to tailor the course to meet the students’ individual needs. I wanted to focus on the transfer of strategy use by the students. And finally, I wanted to facilitate transfer by decreasing my role in the students’ learning as the quarter progressed. I believe that all three of these goals were met. In the end:

- Students had been introduced to a variety of mathematics-specific learning strategies tailored to suite their individual needs;
• Students had engaged in discussions about the continued use of these strategies in subsequent mathematics courses; and

• Students had made real choices regarding strategy use. They decided what to do, when to do it, and how much to do.

Many positive outcomes resulted:

• Students reported feeling less teacher-driven;

• Students took responsibility for their own successes and failures;

• Students attributed failures to actions rather than abilities;

• Students became familiar with a variety of different types of resources;

• Students made decisions about when and why to use these resources;

• Students learned to reflect on the outcomes of their decisions; and

• Students gained a sense of control over their mathematical experiences.

All of these outcomes are characteristics exhibited by self-regulated learners.

**The Next Step**

What will these students do next? How will they approach studying and learning in their next mathematics courses? These questions were addressed in the second phase of this investigation. Chapter 5 contains the details of this follow-up. Eight of the students from the strategy-embedded developmental mathematics course participated in this part of the inquiry—Tad, Johnny, Jake, Donovan, Kelly, Mary, Rachel, and Estelle. Their approaches to studying and learning in college algebra were analyzed and are discussed in the following chapter.
CHAPTER 5

THE PARTICIPANTS' APPROACHES TO LEARNING IN COLLEGE ALGEBRA

"Understanding how learners develop and use self-regulated learning when they study alone may uncover principles for designing better resources."
(Christ, 1995, p. 174)

Introduction

Eight of the students who completed the strategy-embedded developmental mathematics course were interviewed as they progressed through their first college-level mathematics course. Four additional students also participated in this phase of the investigation. In this introduction, the reader will find information about the 12 participants, an overview of the college algebra course, and a review of the methodology employed herein.

The Students

The primary participants in the second phase of the current investigation were eight of the students who had completed the strategy-embedded developmental mathematics course—Tad, Johnny, Jake, Donovan, Kelly, Mary,
Rachel, and Estelle. Data supplied by the secondary participants—students who were not enrolled in the strategy-embedded course—were used to enrich and enhance the primary research data. In order to distinguish the primary and secondary participants, the newcomers to the investigation—the secondary participants—have been referred to as S1, S2, S3, and S4 throughout this chapter.

**Primary Participants**

Twelve students who completed the strategy-embedded developmental mathematics course enrolled in a college algebra course during the winter quarter. Eight of these students agreed to participate in the current phase of this investigation. Four of the 12 students were unable to participate because work or extracurricular activities (sorority/fraternity rushes) limited their time. A summary of the primary participants' performance in developmental mathematics can be found in Figure 40.

<table>
<thead>
<tr>
<th></th>
<th>Quiz Average in Developmental Mathematics</th>
<th>Attendance Rate in Developmental Mathematics</th>
<th>Final Course Grade in Developmental Mathematics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tad</td>
<td>92%</td>
<td>96%</td>
<td>A</td>
</tr>
<tr>
<td>Johnny</td>
<td>99%</td>
<td>88%</td>
<td>B</td>
</tr>
<tr>
<td>Jake</td>
<td>93%</td>
<td>100%</td>
<td>B-</td>
</tr>
<tr>
<td>Donovan</td>
<td>84%</td>
<td>94%</td>
<td>C</td>
</tr>
<tr>
<td>Kelly</td>
<td>92%</td>
<td>88%</td>
<td>B-</td>
</tr>
<tr>
<td>Mary</td>
<td>72%</td>
<td>82%</td>
<td>B-</td>
</tr>
<tr>
<td>Rachel</td>
<td>96%</td>
<td>90%</td>
<td>A</td>
</tr>
<tr>
<td>Estelle</td>
<td>94%</td>
<td>96%</td>
<td>B+</td>
</tr>
</tbody>
</table>

Figure 40: Developmental mathematics course results
In their initial interviews, the primary participants provided retrospective descriptions of their experiences in the strategy-embedded developmental mathematics course. An overview of these discussions follows.

**Tad.** Tad knew what it took to be successful in the developmental mathematics course. He was interested in learning the material because he wanted to build a strong foundation before moving on to college-level mathematics courses. He was still learning how to "juggle" a full course load—to make time for all that he needed to do. He was, however, willing to take responsibility for his own actions. When he neglected mathematics (and failed a quiz as a result) in order to prepare for a psychology midterm, he was aware of the possible consequences of this decision.

When Tad had to miss more than 25% of his college algebra lectures because of an automobile accident and related injuries, he was unwilling to drop the course. He stuck with it because he felt that, "even if [he] didn't pass, [he] would get something out of it." He remained in the class through the end of the term. At this time he transferred to a college near his hometown (and his regular physician).

**Johnny.** Johnny reported that the developmental mathematics course was his "favorite class" during the autumn quarter. He was initially a poor predictor of examination questions. He also underestimated the amount of effort required on his part to succeed in the developmental mathematics course. When asked
about his approaches to studying at the beginning of the autumn quarter, he reported that “[he] didn’t think [he] had to [study].”

He continuously improved as the autumn quarter progressed. By the end of the term, he reported that his approaches to learning in developmental mathematics included: attending every class lecture, completing all the homework assignments on a regular basis, purchasing and using practice examinations (which he did not do at the beginning of the quarter), and reading the textbook to “fill in the gaps.” With respect to college algebra, Johnny planned to continue using these strategies and to “set up a better study area” in his dorm room.

Jake. Jake reported at the beginning of the developmental mathematics course that he liked to just “let things happen.” He was the only student with a perfect attendance record in the developmental mathematics course. He seemed to regard regular attendance as the most important thing he could do to promote success. Jake admitted however that sometimes he found it difficult to pay attention during the mathematics lectures and this was something he needed to improve. Jake planned to “complete all the homework and pay attention” during the college algebra course. He also planned to schedule time for studying because he had a tendency “to get lazy.”

Donovan. Donovan completed all his homework assignments and used every resource available to students during the developmental mathematics course. On his examinations, however, he would get so “stressed out that [he] would make little mistakes at the end of each problem.” He said that he learned
to relax as the quarter progressed and to refine his approaches to the course. He
found himself “doing less and learning more.” Donovan reported that he planned
to sign up for a tutor for college algebra from the office of minority affairs—
something he “should have done for the developmental mathematics course.”

**Kelly.** Kelly, like Johnny, was enthusiastic about college and about the
developmental mathematics course. She liked to sit at the front of our class
because she knew she was easily distracted. Like many freshmen, she was still in
the process of learning to manage her time. She reported that she often put off
studying for developmental mathematics because she had to read psychology or
write a sociology paper. Kelly plans to become an elementary school teacher and
could not wait to finish college algebra because then she could begin “the fun
math courses for elementary teachers.” Kelly thought it would be important to
find someone to study with (a "study buddy") in college algebra.

**Mary.** Mary reported having extreme test anxiety. Her boyfriend even
suggested that she should “take a hit” before her mathematics exams so she would
be able to relax a little—she did not take his advice. Mary was always surprised
by her own success. She expected to fail the exams, yet she did quite well in
developmental mathematics. After analyzing her examination errors in the
developmental mathematics course she reported that she “couldn’t believe what
stupid mistakes she was making.” These observations, however, did not serve to
improve her self-efficacy for doing mathematics. Mary dropped college algebra
after taking the first examination because she “knew she failed and there was no point in continuing.” Mary did not fail the first exam—she got a 60% (D).

**Rachel.** Rachel was willing to try any of the learning strategies that were introduced in the developmental mathematics course. She was surprised and delighted to learn how to predict examination questions. She liked the study session goal sheets and continued to use them throughout the term. She was extremely accurate in her analysis of her examination errors. Rachel, who was typically quiet and reserved throughout the developmental course, planned to ask more questions during college algebra. According to Rachel, if she had questions she would go to her instructor’s office hours or to the tutoring center.

**Estelle.** Estelle, like Mary, reported having extreme test anxiety. Estelle felt that her anxiety, however, had decreased tremendously by the end of the developmental mathematics course. She was more in control of her learning and grew increasingly confident during testing situations. She recognized that her performance was linked to her actions. She saw that when she skipped some of the homework assignments, for example, she missed the corresponding exam questions. She planned to do all her homework assignments for college algebra.

**Secondary Participants**

Four students who had not enrolled in the strategy-embedded developmental mathematics course, but did take a developmental mathematics course during the autumn quarter, also participated in the investigation. These
four students, like the primary participants, were enrolled in a college algebra
course during the winter 1998 quarter (see Figure 41).

These participants reported doing their homework assignments in
developmental mathematics, visiting the mathematics tutoring lab once or twice,
and rarely (or never) reading their textbooks. Their approaches to studying for
examinations in developmental mathematics were to “go over all the stuff before
the exam” or “do the review sheets.”

<table>
<thead>
<tr>
<th>Final Course Grade</th>
<th>Developmental Mathematics</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1 (male)</td>
<td>B-</td>
</tr>
<tr>
<td>S2 (female)</td>
<td>C</td>
</tr>
<tr>
<td>S3 (female)</td>
<td>B+</td>
</tr>
<tr>
<td>S4 (male)</td>
<td>B</td>
</tr>
</tbody>
</table>

Figure 41: Final course grades

These four students were each interviewed three times during the winter
quarter—once prior to the first college algebra exam, once after the first exam,
and once after the second exam. At this point, data were becoming repetitive—no
new information resulted. These data were used to highlight similarities and
differences in the approaches to studying and learning employed by the two
groups of participants.
The College Algebra Course

Students enrolled in college algebra (Math 104) at the Ohio State University attend a 50-minute lecture class three days each week (Monday, Wednesday, and Friday) and a 50-minute recitation class on each of the remaining two days (Tuesdays and Thursdays). The lecture halls used for college algebra hold 100 to 300 students, while the recitation rooms are limited to 32 students. Undergraduate mathematics majors often lead recitation sections. Recitation formats range from question-and-answer sessions to lecture-style (re)presentations of the material covered in lectures.

Course Content

The textbook used for the college algebra course was Intermediate Algebra (3rd Ed.) by Johnson & Steffenson (Harper Collins College Publishers, 1994). Chapters 2 through 7 were covered in the college algebra course along with selected topics from additional chapters. The main ideas for these chapters are:

- Chapter 2—Linear Equations and Inequalities;
- Chapter 3—Graphs, Relations, and Functions;
- Chapter 4—Systems of Linear Equations;
- Chapter 5—Polynomials and Factoring;
- Chapter 6—Rational Expressions; and
- Chapter 7—Radicals and Rational Exponents.
Additional topics included completing the square, the quadratic formula, and the properties of quadratic functions.

**Course Evaluation**

Three common examinations (100 points each) were administered throughout the quarter as well as one comprehensive final examination (200 points). These exams, like those in developmental courses, were designed by a course coordinator and were not made available to instructors prior to administration. One portion of the students’ grades (50 points) was left to the recitation instructor’s discretion.

On the first day of the quarter, students were given a common syllabus, which included a day-by-day lecture schedule and a list of recommended homework problems from the textbook. Three sets of homework problems can be found in the text—regular exercises, parallel exercises, and enrichment exercises. Students were *encouraged* to do the regular exercises. The solutions to these exercises are found in the back of the textbook. Two or three problems from the parallel exercises (similar to the regular exercises, but without solutions in the text) were assigned from each section. Students were *required* to turn in these problems to their recitation instructors. Enrichment exercises were neither assigned nor recommended.

Each of the three major examinations consisted of 10 problems worth 10 points each. Students were given 50 minutes to complete these exams. The final examination consisted of 20 questions worth 10 points each for a total of 200
points. Students had one hour and fifty minutes to complete the comprehensive final examination.

**Winter 1998 Results**

Median examination scores reported by the mathematics department for the three college algebra examinations were 75% (Exam 1), 60% (Exam 2), and 60% (Exam 3). The median score reported for the comprehensive final examination was also 60%. Details of these results are found below (Figures 42 and 43).

<table>
<thead>
<tr>
<th>Grade</th>
<th>Exam 1 (Median 75%)</th>
<th>Exam 2 (Median 60%)</th>
<th>Exam 3 (Median 60%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Percent</td>
<td>N</td>
</tr>
<tr>
<td>A</td>
<td>170</td>
<td>25.84%</td>
<td>16</td>
</tr>
<tr>
<td>B</td>
<td>155</td>
<td>23.56%</td>
<td>69</td>
</tr>
<tr>
<td>C</td>
<td>120</td>
<td>18.24%</td>
<td>153</td>
</tr>
<tr>
<td>D</td>
<td>72</td>
<td>10.94%</td>
<td>180</td>
</tr>
<tr>
<td>E</td>
<td>141</td>
<td>21.43%</td>
<td>316</td>
</tr>
</tbody>
</table>

Figure 42: Grade distributions for college algebra major examinations

While approximately 70% of the students earned grades of C or above on the first examination, only 30% (approximately) earned grades of C or above on the second and third examinations.
<table>
<thead>
<tr>
<th>Grade</th>
<th>N</th>
<th>Percent</th>
<th>N</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>52</td>
<td>7.57%</td>
<td>105</td>
<td>16.23%</td>
</tr>
<tr>
<td>B</td>
<td>95</td>
<td>13.83%</td>
<td>132</td>
<td>20.39%</td>
</tr>
<tr>
<td>C</td>
<td>118</td>
<td>17.18%</td>
<td>140</td>
<td>21.63%</td>
</tr>
<tr>
<td>D</td>
<td>117</td>
<td>17.03%</td>
<td>92</td>
<td>14.22%</td>
</tr>
<tr>
<td>E</td>
<td>305</td>
<td>44.4%</td>
<td>178</td>
<td>27.51%</td>
</tr>
</tbody>
</table>

Figure 43: College algebra final exam and course grade distributions

Nearly half of the students enrolled in college algebra failed the comprehensive final examination (44%). In the end, approximately 72% of the students enrolled in college algebra passed the course (with a grade of A, B, C or D).

**Student Participants’ Results**

Examination results for the primary participants in the current phase of this investigation are presented in Figure 44. Tad, Donovan, and Rachel scored above the median on all three college algebra examinations. Jake scored below the median on all three exams.
<table>
<thead>
<tr>
<th></th>
<th>Exam 1 (median 75%)</th>
<th>Exam 2 (median 60%)</th>
<th>Exam 3 (median 60%)</th>
<th>Course Grade (median 70%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tad</td>
<td>86</td>
<td>74*</td>
<td>64*</td>
<td>D</td>
</tr>
<tr>
<td>Johnny</td>
<td>80</td>
<td>71</td>
<td>57</td>
<td>C</td>
</tr>
<tr>
<td>Jake</td>
<td>52</td>
<td>40</td>
<td>57*</td>
<td>E</td>
</tr>
<tr>
<td>Donovan</td>
<td>76</td>
<td>68</td>
<td>71</td>
<td>C</td>
</tr>
<tr>
<td>Kelly</td>
<td>52*</td>
<td>63</td>
<td>54</td>
<td>D</td>
</tr>
<tr>
<td>Mary</td>
<td>60*</td>
<td>withdrew</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rachel</td>
<td>91</td>
<td>74*</td>
<td>70</td>
<td>B</td>
</tr>
<tr>
<td>Estelle</td>
<td>58</td>
<td>72*</td>
<td>81*</td>
<td>C</td>
</tr>
</tbody>
</table>

* student's self reports

Figure 44: College algebra exam scores and final course grades for Winter 1998

Partial examination data for the additional participants can be found in Figure 45. Data were only collected during the students' weeks of participation.

<table>
<thead>
<tr>
<th></th>
<th>Exam 1</th>
<th>Exam 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>71%</td>
<td>65%</td>
</tr>
<tr>
<td>S2</td>
<td>64%</td>
<td>59%</td>
</tr>
<tr>
<td>S3</td>
<td>78%</td>
<td>70%</td>
</tr>
<tr>
<td>S4</td>
<td>61%</td>
<td>53%</td>
</tr>
</tbody>
</table>

Figure 45: Self report data on study participants who were not enrolled in the embedded developmental mathematics course

**College Algebra Lectures**

During the winter term, I attended five college algebra lectures. While observing these presentations I sat at the back of the lecture halls and took notes as if I was enrolled in the course. Lecturers typically used microphones and two
overhead projectors during their presentations. The lecturers walked from one overhead to the next as they discussed examples. This was done so that the students had time to write down the information.

Several times during the lecture presentations, the lecturers would call for questions ("Any questions?"). Perhaps this was done out of habit. The lecturers typically did not look up to see if the students needed clarification. Students reported that they reserved their questions for recitation.

All of the lectures I observed were extremely clear. Examples were carefully selected to represent the various types of problems found in the homework assignments. Difficult problems and concepts were emphasized, and more time was devoted to the explanations of these problems.

Attendance fluctuated throughout the 50-minute lecture periods. Students walked in and out of the lecture halls. Approximately 40 students were in attendance at any given time during the lectures I observed.

The instructors I observed did not discuss connections among topics or situate the new material within the students’ existing body of knowledge. Main ideas and themes were not discussed. Examples, for the most part, were presented in isolation.

While discussing the lecture-recitation format over dinner, the primary study participants agreed that this instructional style was disconnected. They commented that:
*Kelly:* It doesn’t seem like you need to go to both; recitation is just a repeat of lecture.

*Estelle:* We tried to get [our recitation instructor] to do things like go to the lectures, but she didn’t have time to go to lecture.

*Rachel:* The [recitation instructor] and the lecturer need to communicate better. We’ll ask our recitation instructor something and he will say ‘well I don’t know, I don’t know what he told you in lecture.’ And I know that the lecturer has all those people in his class, but I think it should be part of his job description to communicate. It’s just hard to connect the two classes.

**This Chapter**

In this chapter, data were used to uncover the primary participants’ self-regulatory practices with respect to college algebra. The students’ experiences were synthesized resulting in a cross-case analysis, rather than multiple case studies. Data from multiple sources (interviews, documents, and observational data) were used to identify key themes and issues.

The three major cyclical phases of self-regulated learning theory, identified by Zimmerman (1998), were used as an organizational mechanism for analyzing the data collected during the second phase of the current investigation. Students’ decisions, thoughts, and actions with respect to forethought, performance, and self-reflection (the three major cyclical phases) are discussed herein. This discussion is followed by a thematic analysis of the data.

**Cyclical Phases of Self-Regulation**

According to Zimmerman (1998), “For an academic skill to be mastered, learners must behaviorally apply cognitive strategies to a task within a
contextually relevant setting. This usually involves repeated attempts to learn because mastery involves coordinating personal, behavioral, and environmental components, each of which is separately dynamic as well as jointly interactive” (p. 2). This process is viewed as both open-ended and cyclical with activity occurring in three phases: forethought, performance, and self-reflection.

Goal setting and strategic planning occur in the **forethought phase** of self-regulatory activity. Skilled self-regulators set realistic goals and develop detailed plans of action for attaining these goals. Both goals and plans are affected by a number of personal factors such as a student’s self-efficacy for learning (belief’s about one’s capability to learn), goal orientation (performance goal orientation or learning goal orientation), and intrinsic interest.

During the **performance phase** of self-regulatory activity, skilled learners engage in activities to optimize their performance. These activities may include attention focusing, self-instruction, and self-monitoring. It is during this phase that learners carry out their plans of action.

**Self-reflection** follows performance in the cycles of academic self-regulation. During the self-reflection phase, learners make judgments about their progress (self-evaluation). These judgments often lead to attributions of successes and failures. “Self-regulated learners tend to attribute failures to correctable causes and successes to personal competence” (Zimmerman, 1998, p. 5). Learners use these reflections and judgments to adapt performance. Adaptation
may be refined through many practice cycles before learners discover the approaches that work best for them.

The students who enrolled in the strategy-embedded developmental mathematics course during the fall quarter of 1997 were guided through these phases of self-regulatory activity. Instruction focused on helping students develop appropriate self-efficacy beliefs, set realistic goals, and devise specific plans of action for attaining those goals (forethought phase). Tools for monitoring progress (checking homework solutions with answers found in the back of the text, for example) and focusing attention were discussed throughout the term (performance phase). Self-reflection was also a major component of instruction during the strategy-embedded course. Students learned to appropriately attribute their successes and failures and to adapt and refine their plans of action.

Were the 19 developmental mathematics students developing self-regulatory skills? Or were these students merely adapting to the demands of the strategy-embedded developmental mathematics course? The second phase of the current investigation—the focus of this chapter—addresses these questions. Data indicate that students continued to engage in productive self-regulatory activities even when these activities were no longer required.

**Forethought Phase**

In this section, students’ goals and plans of action with respect to their college algebra courses are revealed. Data address the following questions:
• How did students prepare for learning? This refers to the types of goals set by the students and the plans of action they developed.

• What factors influenced students' goals and plans? Self-efficacy, intrinsic interest, and goal orientation are possible factors. Self-reflective activities may also affect goals and plans (forethought processes).

Because the three phases of self-regulation—forethought, performance, and self-reflection—are cyclical, it is difficult to discuss one phase without referring to activities related to other phases. For this reason, some of the data reported herein overlap discussions in other sections of this chapter.

The primary participants, with the exception of Mary, set performance (grade) goals that slightly exceeded their typical performances. They had a tendency to aim high without letting their results negatively affect their self-efficacy perceptions. The primary participants' goal setting activities, however, were not limited to grade-related goals. They also developed goals for learning the material as well as plans of action for attaining their goals.

**Tad**

Although Tad was majoring in art history, he professed a strong interest in mathematics. He was confident in his ability to succeed in college algebra: "I know what it takes to do well, and I know I can do it. But I'm still working out those time management kinks." He recognized that time management was his
weakness and had been working on developing a study schedule that “worked for him” since the autumn quarter. He was not surprised that his LASSI scores had indicated a need to improve his time management skills. He had used the study session goal sheets during the developmental mathematics course and had purchased a calendar planner for use during the winter quarter.

Tad’s primary goals during the winter quarter were related to time management. According to Tad, “My goal is to keep up this quarter. I don’t want to fall behind. This means I need to read the book before class and do the homework as we talk about the stuff.” Tad knew what he needed to do to be successful in college algebra. He followed this plan and scored 86% on his first exam.

Shortly after the first exam, however, Tad’s goals and plans had to be drastically modified. Tad was in an automobile accident and was suffering from severe headaches. Tad commented, “I guess this is life. I never expected to miss so many classes. I’ll just get as much as I possibly can out of the course. I can still learn quite a bit even if I can’t get it all. I’ll probably have to start over, but at least I’ll be ahead of the game next time.” Even under these circumstances, Tad was planning ahead.

Johnny

Students who are placed in a developmental mathematics course during their first college term are often shocked and devastated—not Johnny. He understood why he had been placed in the remedial course. “I didn’t take math
my senior year in high school, which I should have because that's why I ended up in developmental mathematics.” This placement did not affect his confidence or his self-efficacy for learning mathematics. “If I work hard enough in math class I know I could get an A.”

Johnny’s interest in math was limited. He needed college algebra for his degree, but did not need to take any additional math courses that relied on the knowledge he would acquire. “My goal this quarter is to get a B—I know I could get an A but I just don’t want to work that hard. My next math class is logic and stuff like that, so I really just need to get a C so that I can go on.”

When I asked Johnny about his study plans for the winter quarter, he began his response by reflecting on his developmental mathematics course experiences. “Last quarter I didn’t think I had to study for math at first—well, like the first month. After I took the first test I realized, ‘Wow.’ I thought this was going to be an easy class and on the first test I got a D. And then I started to think ‘Oh man you know I must have missed something here or there.’ I didn’t do the review sheet the first time and I didn’t do the practice test. But then I started doing the review sheet and I started reading the book myself and my grade went from a D to a C, then a B. So that worked out. I also studied with Kelly and Vernon last quarter and the stuff I didn’t know, well Kelly would know.”

Like Tad, Johnny struggled with time management issues with respect to planning. “I have to learn how to manage my time. Like last quarter, I threw my whole self into math and then I fell behind in psychology. So like I try to
catch up and then I stop focusing on math and then my grades start to go down, and like ‘Man, what am I doing?’ So, I think once I figure out what I have to do and how much time I have, I’ll be fine.”

Johnny solicited advice from friends who had already taken college algebra before developing his plan of action. “I go to all the recitations because my friends told me you have to go and I took their word for it. For me, I have to go to the lectures too. I’m definitely reading the book after each lecture. Some stuff makes sense when I read it, some stuff doesn’t. Like I had to read the stuff on the point-slope formula three times because when I read it I was like, ‘What are they talking about?’ I just kept reading it until it would sink in. I do absolutely every exercise in the book—not just the even or just the odd—that’s my plan.”

Johnny said that he had not planned to study with Kelly and Vernon at the beginning of the college algebra course because they were in different lecture classes and “it was easier when [they] all had the same teacher and were all in the same class.” Johnny eventually began to study with Kelly.

Johnny’s plans were modified several times throughout the winter quarter. After scoring an 80% on the first exam, he decided that he probably didn’t need to do as much of the homework as he had been doing. He later confessed: “I slacked off a little bit between test 1 and test 2. I missed a few classes and stopped doing all the extra homework. Now I’m going to start going to class and
do all the homework and read the book again—I didn’t really read the book this last time.”

Although Johnny was not happy with his second test score (71%), he was still confident in his ability to do well in mathematics. “Everybody keeps telling me that it’s going to be hard, and I don’t think it’s that hard. If I could take the test over again, I know I would get an A. I know I could get those problems right if I actually took enough time.”

Johnny began planning for the final exam early in the term. “I’m going to start studying for the final as soon as I get my second test back. I’ll put all my tests together with the practice tests and review sheets and work them out again. I’ll also study with Kelly and Jesse—this guy I play basketball with. I asked a couple of friends if they would help me out if I needed help—they’re in a higher math class than me. I think most of the stuff I don’t know is because I haven’t given myself the time to learn it. If I had more practice, I would have known how to do it.”

**Jake**

Jake’s interest in mathematics was in flux. According to Jake: “Last quarter my interest was high in math because it was totally new stuff. This quarter it’s going down because things are going too fast.” Things were moving very quickly for Jake during the winter term—partially because he had enrolled in 20 quarter-credit hours! He did not realize what he had gotten himself into at the
beginning of the term, and unfortunately his academic advisor was unaware of his course load until it was too late for him to drop any of the classes.

Jake's self-efficacy for learning mathematics was high. Jake commented about his college algebra course, "I know I could do this if I had enough time." At the beginning of the term, he carefully scheduled his study sessions. "For the first two weeks of the course I worked on math a half an hour every night—I read over the notes and did the homework—just the problems we had to turn in. To prepare for the first test, I decided to do the practice test and to go over it in my instructor's office right before the exam."

After failing the first exam (52%), he decided to modify these plans. "Now I'm going to set aside time to work all the problems—not just the ones we have to turn in—and to go to his office hours to make sure I am doing everything right." When these efforts proved to be insufficient—Jake scored a 40% on the second exam—Jake decided to discontinue his mathematics study sessions and to devote his time to his other courses.

Jake, like Tad, continued to attend the college algebra lectures and even took the third test because then he "would have something to study next time he took the course." These failures, however, did not affect Jake's confidence in his ability to succeed in college algebra—"I should have never taken 20 hours. That's why I couldn't do this. I just didn't have the time."
Donovan

According to Donovan, “Math is my weakest subject. All through school I have never been good at math, and I’ve never seen the point in it. But I know I can do this [college algebra] if I study hard and stick with it on a daily basis. For me, study hard means that I need to understand the problems, if I don’t understand then I need to ask my tutor or go to the math lab.” Donovan was confident in his ability to succeed—“I know that I could get 100% on the tests if I worked hard enough.”

Donovan was also interested in learning the college algebra content. “I want to get an A and to understand the material so I can be successful in my next math course.” He believed that high grades reflected deep understanding. For this reason, “[his] main focus was to get the highest grade possible.”

Before the quarter began, Donovan had already decided that if he were not satisfied with his instructor, he would find another. Donovan did just that. “I switched sections on the first day because I didn’t understand my teacher, so I found a new one. I had to do something. So I started looking for a better lecturer and visiting classes because we did that visiting stuff last quarter. I’m satisfied with my new instructor.”

Donovan, like Johnny, sought the advice of friends before developing a plan. “My roommates took college algebra last quarter and they’re in it again. I see their mistakes—they told me that they didn’t do enough practice, they only did what they had to turn in. I’m doing both parallel and recommended
homework exercises right now. I’m trying to keep myself to five problems per day. Last quarter I got all stressed out, so I know I need to keep from doing that this quarter.”

Donovan was willing to revise his study plans as needed. “If I’m happy with my grade, then I’ll continue to do what I am doing, otherwise...” Donovan slightly modified his approach to studying after the first exam. “I have already started the homework for the next section [before attending a lecture on the material]. I’m trying to stick to five problems per day so I can keep up with and know what I’m doing and I won’t have to do so much of that cramming. I’m trying to relax more and to just stay cool and calm this quarter. I’m also going to start going to the Math-Stat Learning Center because I have a lot of time during the day. Now when I study I try to make sure that I know how to do every type of problem—like all the kinds of factoring problems, for example.”

Donovan had also developed strategies for test taking. “Before I took the [first] test, I decided that if it was like the practice test that I was going to start at the back because I knew that stuff better. The work problem I decided I would just kind of leave it alone because I’ve always had trouble with those, and I can miss 10 points and still get a decent grade [76%]. For the second test, I originally decided that I would start with the first problem and work straight through, but that changed.”

Throughout the quarter, Donovan was always looking ahead. “I have already looked through people’s books for the next math course. I know it’s
going to be hard but I can do it. Next quarter I need to work harder on my time management because I am taking four classes. I need to schedule time to do my math right after class. I know what I’ve got to do now better than what I knew the first quarter.”

Kelly

Kelly openly discussed her confidence, interest, and motivation with respect to college algebra. “My confidence level is good. I don’t think it’s that I can’t do it. I think, ‘Oh, wow, I really need to do this’, and I can do it. I know I can learn this stuff as long as I take the time to do the work and learn the formulas. I also need to learn how to do all the graphing stuff and how to use my calculator. I know I can get in the 80s on any test, I’m just not motivated to work that hard. My interest level in college algebra, on a scale from 1 to 10, is well maybe a 7. English is a 10.”

Kelly’s plan of action for succeeding in college algebra included attending all the class meetings, organizing a useful notebook, and completing all the required homework assignments. “I planned to spend 1 hour each night studying for Test 1 and I did. I’m going to spend at least two hours a night studying for Test 2. When it comes to the final, I’m going to look at all my exams and corrections and the book and my notes. I will make up a little practice test because I did that last quarter and it helped. I’m also getting together with Johnny.”
Kelly, who had struggled with time management issues both this quarter and last, developed a plan for her last minute [just-before-final-exams] reviews. “I have a sociology final on the same day as my algebra final—Tuesday. On Monday I will study for both math and sociology—split the day—and on Tuesday I will study for math again after my sociology exam.”

Mary

Mary opened our first interview with, “I am extremely frustrated. Math is the worst subject for me.” She had lost all confidence in her ability to succeed and was unable to develop a new plan of action. She had begun the term with a plan. She attended every lecture, attempted all the homework problems, and went to her instructor’s office on three different afternoons to get assistance. She believed, however, that she had failed her first exam miserably and this was the source of her frustration. (In reality she scored a 60%.)

I asked Mary what she could do to get through the course. She replied, “I don’t know.” I asked her if there was any place she could go for help. She responded, “I don’t know.” She stopped attending class because she did not want to see her exam results. By the time she picked up her exam and realized she could still pass the course, she had already missed too many lectures. Mary dropped the course.

Rachel

Rachel was motivated to learn in college algebra. “I wanted to make sure that my homework was correct—the work, not just the answers—because I’m
gonna be using it in the next class.” Rachel would need to complete at least one more mathematics course beyond college algebra for her major—food science. “I used to think of myself as an average math student—C or D. When I came to college, I just decided to break the cocoon and to really go for it. You know, do everything that I possibly can to get the best grade that I possibly can.”

“My goal this quarter is to get an A in math.” Rachel set both long term and short term goals throughout the quarter. During one of our interviews, for example, she stated that, “My goal for this weekend is to go over those chapters that I didn’t understand on the last test [test 2]. I need to go back and learn this stuff because it is going to be on the final.”

Rachel, like several of the other student participants, wanted to learn from the mistakes of others. “A lot of people in my class are taking the course for the second time, so I asked what they did to fail last time. They said to do your parallel exercises. I think it was because they didn’t keep up with the homework.”

Several of the study participants observed that a significant percentage of the students enrolled in their college algebra courses were taking the course for the second time. Rachel recognized that they were “catching on” more quickly because they had seen the material before. She did not let their relative success affect her own confidence or self-efficacy for doing mathematics. These “repeaters” actually motivated her to “not be one of them.” According to Rachel, “People who are taking the course over are getting all these high grades.
But that's not going to be me because I know I started off with a 91% and people were like amazed because it was my first time in the course. You don’t have to take the course twice to get it.”

Rachel planned to use a modified version of the study session goal sheets to plan her week. She decided that it would be important for her to attend all the lectures and to complete both the required and recommended homework assignments. “I know how I am at math. I need to take my time and write everything down.” Rachel spent “an hour and a half to two hours studying on Tuesdays and Thursdays and weekends.” She also took her math book with her to work [a federal work-study appointment] so she would have something to do when there was no work to be done. Rachel always thought ahead.

Rachel began studying for the college algebra final exam immediately after the return of the first exam. “I need to start studying right now [after Exam 1] for the final exam—start off with the section we started with [in the class], write down the rules and stuff and some problems to do. In math, for me, it's just planning ahead and not waiting until the last minute.”

As the day of the final exam approached, Rachel planned her final study sessions. “Some people are going to study and stay in their rooms all weekend. I figure if you don’t know it now you’re not gonna know it too much better after cramming. I’m going to the two-hour review session and then study on my own. I was invited to another review but I can’t handle being shown too many different ways to do things, because that confuses me. I always have a good idea what is
going to be on the test based on the sample tests and reviews. I'm going to pull all these tests together and the sample tests and things like that and I'm going to go over my notes for the final.”

Like Donovan, Rachel was looking ahead to her next mathematics course. “I met a girl who studied with a group [for college algebra] and got a 100 on the last test, so I want to hook up with her for the next class.”

**Estelle**

Estelle had a very busy winter quarter. In addition to a full course load, she was working two separate jobs—40 hours per week, total. Fortunately for her, she was very interested in mathematics. “I'm majoring in engineering. I like math—I think it is a challenge. Sometimes I get discouraged though. I was kinda discouraged at first when I took the math placement [test] and I placed in the lowest math class [last quarter] because I took calculus in high school. Then after a while I looked at it as a good review.”

Estelle had a plan of action from the beginning of the term. “I go to all my classes and I do all the homework—even the problems that aren’t for a grade. I also decided to do all the practice tests and review problems. I even bought those extra tests. I know I can learn this material if I just start going to the tutoring center and to the recitation instructor’s office hours.”

She was confident in her ability to learn the college algebra material with one exception: “My whole entire schooling I have never been able to do word problems—I don’t know how to take the information and use it. I am bad at word
problems.” After we reviewed her entire first exam, I asked Estelle how well she thought she would do if she were to take the exact exam over again. She replied, “About a C, I guess.” I asked her what she thought she would miss. Without hesitation, she answered, “The word problems.” She really was not having as much difficulty with the word problems as she perceived. She was actually making the same types of sign and arithmetic errors on these problems as she did throughout the exam.

After the first exam, Estelle signed up for a tutor and started going to the Math-Stat Learning Center. Her grades continued to improve and she continued to engage in these activities. By the third exam, she decided to quit one of her jobs because, “It just wasn’t worth it, I needed more time to study and I needed to sleep too.”

**Secondary Participants**

My discussions with the secondary participants regarding their goals and their plans of action with respect to the college algebra course were quite different from my conversations with the primary participants. Perhaps my former students knew what types of questions to expect and planned for our interviews. Or maybe they were just more comfortable conversing with me. Regardless, I found that my questions had to be more probing with the secondary participants—I repeatedly said, “Can you explain what you mean by…”

When asked about his goals with respect to the college algebra course, one student (S1) replied:
SI: I want to do the best I can and get a passing grade.

Interviewer: What does it mean ‘to do your best’?

SI: To do whatever it takes to pass.

Interviewer: What do you think it will take?

SI: Getting good grades on all the tests.

Interviewer: How will you do that?

SI: I guess I’ll have to go to class and do the homework.

This student felt that he would be successful in college algebra because the content looked very similar to the material discussed in the developmental mathematics course. He was motivated to pass the course so that he could take the next mathematics course in the sequence. He planned to go to the lectures and do the required homework assignments, but he was not sure when or where he would study. He really had not thought about how much time he would need to schedule for studying mathematics—“Whatever it takes.”

After SI scored a 71% on the first exam, he decided that doing only the required homework problems was sufficient—he was satisfied with his score and he continued with this approach. Even when he scored a 65% on the second exam, he was still satisfied with this plan of action. After all, according to SI, “the median on the second test was 60 and I did better than that. And I heard they’re probably going to curve it.”

S2 had both a goal and a plan of action. According to S2, “My goal in math is to pass this class and never have to take another math class again.” She
was determined to do just that. She planned to attend every lecture and complete all the required homework problems. She also went to the mathematics tutoring facility twice a week to work on her homework and have the attendants check her work. "I never miss class and I always know that my homework is perfect before I turn it in."

After scoring a 64% on the first exam, S2 had no idea what had gone wrong. She had done all her homework assignments and received perfect scores on each. I asked her how she was going to proceed in the course and she replied, "I guess I'll keep doing the same things I have been doing—going to class and doing the homework. My homework grade will help my average. Maybe I'll try to do more problems, if I have time."

S3 was hoping to get a "high B" in the college algebra course. She attended every class meeting, completed the required homework assignments and participated in the free tutoring available at her dorm. She bought the sample tests at the end of the fall quarter but was unable to find them in her room. S3 said that she is "pretty interested in math," and that she "can do it if she puts her mind to it."

S3 scored a 78 and a 70 on the first two exams in college algebra—she was happy with those scores. Her goal for the class became, "to get a high C or a low B." She was confident that she could do this and that she would be successful in her next mathematics course. Her approach to studying remained
the same throughout our interviews—go to class, do the homework, go to
tutoring.

S4 was willing to do whatever he had to do to succeed in college algebra.
His goal was to pass the course and understand the material so he that could start
taking courses in his major, physical therapy. His plan was to go to class, take
good notes, and do all the homework assignments. After scoring a 61% on the
first exam, S4 began to lose confidence. “I can’t give up yet, but I don’t see how
I can make it if I don’t know that first stuff. I don’t understand what else I could
have done.” S4 continued doing what he had previously done. He dropped the
course after failing the second exam (53%).

Summary

The types of goals set by the primary participants in the current
investigation indicate that most of these students were willing to consider options
beyond the course requirements. The secondary participants, on the other hand,
had a difficult time coming up with specific goals and plans of action that
exceeded course norms. I am not suggesting that the responses and actions of the
secondary participants (n=4) can be used to generalize the goal-setting and
strategic planning tendencies of this entire population (students who passed a
developmental mathematics course that did not emphasize the use of mathematics-
specific learning strategies and who subsequently enrolled in a college algebra
course). Determining these tendencies was not the focus of the current
investigation. I will, however, say that in my experience with this group, the responses of the secondary participants were not out of the ordinary.

The responses given by the primary participants indicated that these students were developing characteristics of self-regulated learners. Other than Mary (who suffered from extreme test anxiety), the primary participants expressed confidence in their ability to succeed in college algebra throughout the term—even when faced with low examination scores. These students revised their plans of action in meaningful ways, and they never seemed to run out of ideas for improving their learning.

In many cases, actions speak louder than words. We have already discussed the students’ goals and plans of action (forethought processes) with respect to the college algebra course. The participants’ related activities are discussed in the following section.

Whenever possible, the activities reported by the students were verified through other sources. For example, if a student reported using a tutoring facility, I confirmed their attendance with the employees at that facility. I also asked to see samples of students’ notes, homework sets, practice exams, goal sheets, calendars, and planners. In addition, I verified group study activities with other members of the students’ groups. When students reported activities such as reading their text, I asked them to model those activities for me.
Performance Phase

Students’ actions associated with studying, learning, and testing in college algebra are discussed in this section. Data address the following questions:

- What learning strategies did students elect to use? This addresses the implementation phase of strategic planning.
- How did students monitor their progress during these performance activities? and
- What mechanisms, if any, did students use for attention focusing?

A summary of the primary participants’ college algebra related activities can be found in Figure 46. Students’ activities during the first third of the winter term are listed under Preparation for Test 1. Activities associated with the middle third are found under Preparation for Test 2, and so forth.

Strategy Use

The primary participants engaged in a variety of activities during the winter quarter in addition to attending algebra class and completing the required homework problems—the typical activities reported by the secondary participants. Tad, Johnny, and Rachel, for example, used their college algebra textbooks as a learning resource throughout the quarter. They reported using their books to clarify information and reinforce ideas. All three students admitted that they had never read a mathematics book before enrolling in the developmental course, and probably would not have thought to do so otherwise.
<table>
<thead>
<tr>
<th>Tad</th>
<th>Preparation for Test 1</th>
<th>Preparation for Test 2</th>
<th>Preparation for Test 3</th>
<th>Preparation for Final</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• read text sections before lectures;</td>
<td>• read text sections instead of attending lectures;</td>
<td>• read text sections instead of attending lectures;</td>
<td>• reviewed course exams;</td>
</tr>
<tr>
<td></td>
<td>• completed required and recommended homework;</td>
<td>• attended few lectures because of auto accident and related injuries;</td>
<td>• attended few lectures because of auto accident and related injuries;</td>
<td>• reviewed copies of old final exams;</td>
</tr>
<tr>
<td></td>
<td>• verified homework solutions;</td>
<td>• completed required homework assignments (Exam 74%, Median 60%);</td>
<td>• completed required homework assignments (Exam 64%, Median 60%);</td>
<td>• attended review session</td>
</tr>
<tr>
<td></td>
<td>• created sample tests;</td>
<td>• attended all classes;</td>
<td>• completed reviews and practice tests (Exam 86%, Median 75%);</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• attended all classes;</td>
<td>• completed reviews and practice tests (Exam 86%, Median 75%);</td>
<td>• attended all classes;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• completed reviews and practice tests (Exam 86%, Median 75%);</td>
<td></td>
<td>• attended all classes;</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Johnny</th>
<th>Preparation for Test 1</th>
<th>Preparation for Test 2</th>
<th>Preparation for Test 3</th>
<th>Preparation for Final</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• read text sections after lectures;</td>
<td>• completed only required homework problems—as per his instructor’s recommendation;</td>
<td>• completed only required homework problems—against his better judgment;</td>
<td>• began preparing for final after second exam;</td>
</tr>
<tr>
<td></td>
<td>• organized and used lecture notes</td>
<td>• worked with a study group;</td>
<td>• worked with a study group;</td>
<td>• reviewed course exams;</td>
</tr>
<tr>
<td></td>
<td>• completed required, recommended and additional homework;</td>
<td>• checked over exam questions;</td>
<td>• read text sections after lecture;</td>
<td>• reviewed copies of old final exams;</td>
</tr>
<tr>
<td></td>
<td>• verified homework solutions;</td>
<td>• attended most classes (Exam 71%, Median 60%);</td>
<td>• completed reviews and practice tests</td>
<td>• attended review session;</td>
</tr>
<tr>
<td></td>
<td>• completed reviews and practice tests;</td>
<td>• attended most classes (Exam 80%, Median 75%);</td>
<td>• attended most classes (Exam 57%, Median 60%);</td>
<td>• worked with a study group;</td>
</tr>
<tr>
<td></td>
<td>• attended most classes</td>
<td></td>
<td></td>
<td>• reviewed notes on new material</td>
</tr>
</tbody>
</table>

Figure 46: Strategies used by primary participants during college algebra
<table>
<thead>
<tr>
<th></th>
<th>Preparation for Test 1</th>
<th>Preparation for Test 2</th>
<th>Preparation for Test 3</th>
<th>Preparation for Final</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jake</td>
<td>• scheduled 30 minutes of study time each night;</td>
<td>• scheduled 30 minutes of study time each night;</td>
<td>• attended every class;</td>
<td>• opted not to take the final exam</td>
</tr>
<tr>
<td></td>
<td>• reviewed lecture notes;</td>
<td>• reviewed lecture notes;</td>
<td>• continued to take notes;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• completed required homework;</td>
<td>• completed required homework and some recommended problems;</td>
<td>• attempted some of the homework;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• completed reviews and practice tests;</td>
<td>• went to instructor with specific questions</td>
<td>• discontinued 30 minutes of mathematics study time</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• went to instructor with specific questions</td>
<td>• attended every class</td>
<td>(Exam 57%, Median 60%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• attended every class (Exam 52%, Median 75%)</td>
<td>• attended every class</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Donovan</td>
<td>• attended every class;</td>
<td>Donovan continued to do everything he had previously done plus:</td>
<td>Donovan continued to do everything he had previously done plus:</td>
<td>Donovan felt that he had been</td>
</tr>
<tr>
<td></td>
<td>• worked on mathematics every day—five problems per day;</td>
<td>• went to the Math-Stat Learning Center with specific homework questions;</td>
<td>• met with a tutor for an additional hour each week (2 hours total);</td>
<td>preparing for the final exam since</td>
</tr>
<tr>
<td></td>
<td>• met with a tutor for one hour each week;</td>
<td>• planned a new test-taking strategy—working front to back</td>
<td>• planned a new test-taking strategy—working problems from easiest to hardest;</td>
<td>the beginning of the quarter. He</td>
</tr>
<tr>
<td></td>
<td>• completed reviews and practice tests;</td>
<td>(Exam 68%, Median 60%)</td>
<td>(Exam 71%, Median 60%)</td>
<td>continued doing everything he had</td>
</tr>
<tr>
<td></td>
<td>• self-testing strategies;</td>
<td></td>
<td></td>
<td>previously done.</td>
</tr>
<tr>
<td></td>
<td>• planned a test-taking strategy—start at the end and work forward;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• attended a Sunday review session;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• studied with his roommate (Exam 76%, Median 75%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Preparation for Test 1</td>
<td>Preparation for Test 2</td>
<td>Preparation for Test 3</td>
<td>Preparation for Final</td>
</tr>
<tr>
<td>----------------</td>
<td>----------------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------</td>
<td>------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Kelly</strong></td>
<td>• attended all classes;</td>
<td>• attended recitations but not lectures;</td>
<td>• attended recitations and most lectures;</td>
<td>• reviewed course exams;</td>
</tr>
<tr>
<td></td>
<td>• organized and used notes;</td>
<td>• copied lecture notes from a classmate;</td>
<td>• copied lecture notes from a classmate as needed;</td>
<td>• reviewed copies of old final exams;</td>
</tr>
<tr>
<td></td>
<td>• completed required homework assignments;</td>
<td>• organized and used notes;</td>
<td>• organized and used lecture notes;</td>
<td>• scored and analyzed mistakes on review problems;</td>
</tr>
<tr>
<td></td>
<td>• allotted one hour each night to mathematical study</td>
<td>• completed required homework assignments</td>
<td>• completed required homework assignments</td>
<td>• worked with a study group</td>
</tr>
<tr>
<td></td>
<td><em>(Exam 52%, Median 75%)</em></td>
<td>• worked with a study group</td>
<td>• attempted additional homework;</td>
<td>• reviewed math notebook;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• studied old course exams</td>
<td>• checked homework solutions;</td>
<td>• prepared sample test questions;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>*(Exam 63%, Median 60%)</td>
<td>• worked with a study group</td>
<td>• attended review session</td>
</tr>
<tr>
<td><strong>Mary</strong></td>
<td>• attended every class;</td>
<td>• stopped attending class;</td>
<td><em>(no longer enrolled)</em></td>
<td><em>(no longer enrolled)</em></td>
</tr>
<tr>
<td></td>
<td>• attempted every homework problem;</td>
<td>• withdrew from the course before her second exam</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• went to the instructor's office for help and reassurance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>(Exam 60%, Median 75%)</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preparation for Test 1</td>
<td>Preparation for Test 2</td>
<td>Preparation for Test 3</td>
<td>Preparation for Final</td>
<td></td>
</tr>
<tr>
<td>-----------------------</td>
<td>------------------------</td>
<td>------------------------</td>
<td>-----------------------</td>
<td></td>
</tr>
<tr>
<td><strong>Rachel</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• set daily and weekly goals for herself;</td>
<td>• set daily and weekly goals for herself;</td>
<td>• set daily and weekly goals for herself;</td>
<td>• began preparing for final after first exam;</td>
<td></td>
</tr>
<tr>
<td>• scheduled study time;</td>
<td>• scheduled study time;</td>
<td>• scheduled study time;</td>
<td>• attended a 2-hour review session the weekend before the final;</td>
<td></td>
</tr>
<tr>
<td>• attended every class;</td>
<td>• attended 80% of the classes;</td>
<td>• attended 80% of the classes;</td>
<td>• reviewed course exams;</td>
<td></td>
</tr>
<tr>
<td>• read/highlighted text</td>
<td>• organized and reviewed class notes;</td>
<td>• organized and reviewed class notes;</td>
<td>• reviewed copies of old exams;</td>
<td></td>
</tr>
<tr>
<td>• planned a test-taking strategy—to write down all given information before proceeding;</td>
<td>• read the text to supplement her attendance;</td>
<td>• completed required and recommended homework assignments;</td>
<td>• reviewed copy of old final exam</td>
<td></td>
</tr>
<tr>
<td>• completed required and recommended homework assignments</td>
<td>• completed required and homework assignments</td>
<td>• studied with her roommate</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>(Exam 91%, Median 75%)</em></td>
<td><em>(Exam 74%, Median 60%)</em></td>
<td><em>(Exam 70%, Median 60%)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Estelle</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• attended all classes;</td>
<td>Estelle continued to do everything she had previously done plus:</td>
<td>Estelle continued to do everything she had previously done plus she quite one of her jobs to free more time for studying.</td>
<td>Estelle continued to do everything she had previously done plus:</td>
<td></td>
</tr>
<tr>
<td>• completed required and recommended homework assignments;</td>
<td>• went to the tutoring center and her instructor for help on word problems;</td>
<td><em>(Exam 81%, Median 60%)</em></td>
<td>• attended review session;</td>
<td></td>
</tr>
<tr>
<td>• completed reviews and practice tests;</td>
<td>• met with a tutor for one hour each week</td>
<td></td>
<td>• began preparing for the final after the first exam</td>
<td></td>
</tr>
<tr>
<td><em>(Exam 58%, Median 75%)</em></td>
<td><em>(Exam 72%, Median 60%)</em></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Johnny, Jake, Kelly and Rachel were amazed that their algebra notes were so useful. All four students had developed note-taking strategies similar to the one introduced in the developmental mathematics course. Rachel was pleased that her notes were so well organized and easy to follow because she “might need to use them in the next class.” Kelly always used a highlighter on her notes to make the formulas and definitions easier to find.

Tad, Johnny, Donovan, Kelly, Rachel, and Estelle attended additional review sessions throughout the quarter. These sessions were optional and often scheduled during weekends. Donovan commented that he “couldn't believe that only three people showed up to one of [his instructor’s] reviews.”

Jake, Mary, and Estelle reported meeting with their instructors one-on-one at least three time during the quarter. Donovan and Estelle used tutors throughout the term. Johnny, Donovan, and Kelly studied with other students.

The strategies used by the primary participants are summarized in the following chart (Figure 47). Recall that all of these options were discussed in the strategy-embedded developmental mathematics course.
<table>
<thead>
<tr>
<th>Strategy</th>
<th>Students who Engaged in this Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>reading the textbook</td>
<td>Tad, Johnny, Rachel</td>
</tr>
<tr>
<td>completing additional homework</td>
<td>Tad, Johnny, Donovan, Rachel, Estelle</td>
</tr>
<tr>
<td>homework problems</td>
<td></td>
</tr>
<tr>
<td>checking homework solutions</td>
<td>Tad, Johnny, Donovan, Kelly, Rachel, Estelle</td>
</tr>
<tr>
<td>creating sample test items</td>
<td>Tad, Donovan, Kelly</td>
</tr>
<tr>
<td>devising testing strategies</td>
<td>Donovan, Rachel</td>
</tr>
<tr>
<td>organizing and using lecture notes</td>
<td>Johnny, Jake, Kelly, Rachel</td>
</tr>
<tr>
<td>scheduling time for study</td>
<td>Jake, Kelly, Rachel</td>
</tr>
<tr>
<td>meeting with course instructor</td>
<td>Jake, Mary, Estelle</td>
</tr>
<tr>
<td>meeting with a tutor</td>
<td>Donovan, Estelle</td>
</tr>
<tr>
<td>working with a study group</td>
<td>Johnny, Donovan, Kelly</td>
</tr>
<tr>
<td>purchasing and reviewing copies of</td>
<td>Tad, Johnny, Kelly, Rachel, Estelle</td>
</tr>
<tr>
<td>old examinations</td>
<td></td>
</tr>
<tr>
<td>attending review sessions</td>
<td>Donovan, Johnny, Tad, Kelly, Rachel, Estelle</td>
</tr>
</tbody>
</table>

Figure 47: Learning strategies used by primary study participants

**Plans and Actions**

As we all know, sometimes our plans and actions are not, in mathematical terms, equivalent sets. For whatever reasons, a student may *plan* one course of action and *engage* in a completely different activity (or no activity at all). Tad, for example, planned to continue reading his text, attending lectures, and...
completing his homework assignments. He had to modify this behavior, however, when the accident occurred.

Although Johnny planned to continue doing all the homework assignments between Test 1 and Test 2, he did not. He decided that he had probably been doing too much—based on his Test 1 score—and could afford to relax. After earning only a 71% on Test 2, he again planned to start doing more homework. Again, he did not.

Jake, on the other hand, did exactly as he planned. Unfortunately his time was quite limited and his minimalist plan of action—although reasonable in light of his course load—fell short of his needs.

Donovan was the only other student who always did exactly as he had planned. Donovan followed his plans to the letter. His only complaint was that he “should have planned more.” He typically felt that there were more things he could have been doing to help him learn the material.

Kelly’s actions always exceeded her plans. She tended to be quite conservative in her goal setting and strategic planning throughout the quarter. Her time management struggles kept her from committing to too many activities. If she found she had the time to engage in an activity as it was occurring—meeting with a study group, for example—she would. Kelly would not, however, make an advance commitment.
It seems that Mary’s plans and actions coincided perfectly—she had no plan, and therefore engaged in no action. Perhaps this is not necessarily the case. She may have planned to be unsuccessful, and succeeded at her failure.

According to Rachel, she always planned to make time for tutoring. “I do need to go in. I would have written down questions and not just gone in there and said ‘teach me everything.’ That’s what I think the tutoring room is for.” She never managed to find the time to use this resource.

Estelle’s plans and actions were on somewhat of a time delay. She made a plan—getting a tutor, for example—and went for weeks saying, “You know, I really do need to go sign up for that tutor.” Estelle would eventually carry out her plans.

**Monitoring**

Students engaged in a variety of self-monitoring techniques related to their activities in college algebra. Tad used self-questioning during reading. This helped him to slow down and focus on understanding. Johnny also used this technique when reading from his text.

Jake, Estelle, and Kelly talked about their struggling attempts to monitor their understanding while studying mathematics. Jake reported that sometimes he “didn’t know he didn’t understand something until he got his test results.” Similarly, Estelle said, “I always think I understand until I go to the test. I learn what I don’t know after the test. In lecture he makes it look real easy. Then I try the homework and it’s not that easy. It’s like you said last quarter, it always
looks easy when someone else is doing it.” Kelly agreed. “My recitation instructor gets to the end of a problem and I think in my head that I know how to do it, but I truly don’t.” According to Kelly, “If I see someone else do it I think I can do it. I have to try it and make sure I really know how to do it.”

Donovan focused on understanding—not just doing—as he completed his homework assignments. When he encountered something he did not understand, he would ask his tutor. Donovan also monitored his anxiety level during testing. “I started doing the test [Test 3] the best I could from the beginning and then I said, ‘Okay let me go to the problems I know I can get.’ So I went straight to the factoring problems and the cube root stuff. My main strategy was to work from beginning to end, but instead of me stressing out on the problems that might make me miss the regular problems, I skipped to the problems I knew how to do. And I like factoring so I just went ahead and did that.”

Rachel also monitored her progress during testing. “When I spend too much time on a [test] problem, I have to make myself move on.” She chose not to dwell on her mistakes, but to learn from them. “I missed that percent problem on a quiz so I had to learn how to do it so I wouldn’t miss it again.”

Rachel recognized that she had been doing a poor job of monitoring at times. “I did the homework on rational equations, but there’s doing the homework and there’s doing the homework. I did it, but I just didn’t understand it. That’s why I missed those problems on the test. I wasn’t understanding when I practiced it.”
Rachel continued her discussion of understanding. “You can do a lot, but it may not do any good, right. You could have zillions of flashcards, notes, other people’s notes, and...if you are not understanding or your mind isn’t there, if you can’t put things together, you know, then it’s just not going to work.

**Attention Focusing**

Learning requires focus and concentration. I asked the primary participants about their attention focusing efforts. Tad said that coffee (caffeine) was his key. “I always take a cup of coffee with me to the lectures.” Kelly and Rachel found that sitting on the front row during lecture was quite effective. Rachel said, “I always sit at the front of the class—no distractions. I focus on taking notes and understanding what [the lecturer] is saying and I use the book as a resource because it’s hard to keep up with those two overheads.”

Johnny admitted that he found it difficult to study in his dorm room. When he wanted to study, his roommates often wanted to watch television or sleep or play music. Johnny was still adjusting to dorm life. “I need to find a good place to study, some place I can concentrate.”

Jake found that he could focus his attention on learning mathematics as long as he established a scheduled time every night for doing mathematics. “It was my math time.” Donovan said he was able to focus “as long as [he] was relaxed.”
Secondary Participants

The learning strategies most often reported by the secondary participants were attending lectures and completing required homework assignments. Two of the students (S2 and S3) also made use of various tutoring facilities. S2 reported that she had to go to tutoring because, “I don’t really get it until somebody sits down and really explains it to me.”

The actions of these participants were closely tied to their course activities. If the instructor used a review sheet, for example, these students completed the review. None of the four students used textbooks as resources, reported actually using the notes they had taken during lectures, or sought resources in addition to those mentioned above. Textbooks merely housed homework problems, and notetaking was used to help students focus during lectures. According to S1, “Once I write it down, I know it.”

When asked about their self-monitoring techniques (What do you do to make sure you understand the information?), the students replied:

S1: I know I understand when I get the answers right.

S2: You never really know if you know it until you take the test.

S3: If I can do a lot of problems just like them, then I understand.

S4: I guess by your homework grade.

The secondary participants reported using attention-focusing techniques similar to those mentioned by the primary participants. They talked about the
merits of caffeine, the importance of finding a place to study, and the need to learn to relax and concentrate.

**Summary**

The primary participants (with the exception of Mary) used a variety of strategies to approach studying and learning in the college algebra course. They were not engaging in these activities just to be doing *something*. They were looking for productive and effective ways to facilitate their own learning—the right fit, if you will. Most of the activities mentioned by the students had been introduced during the strategy-embedded developmental mathematics course. Students practiced many of these strategies during the autumn quarter, and they received both feedback and support throughout the process of acquisition.

Were the primary participants engaging in these strategies because of their continued involvement in the current investigation? I believe that this was not the case. I did not see the participants on a daily or even weekly basis during their enrollment in the college algebra course. I met with them every third week of the term. Yet they were engaging in multiple learning strategies throughout the quarter.

I attempted to make it clear to the students at every interview that I was interested in their lived realities, and I supported and respected their choices and decisions. I was no longer their instructor, no longer the advice-giver. I believe that they were comfortable sharing their realities with me. Many of the primary
participants, for example, readily admitted that they had planned to engage in an activity but never actually followed through on their plans.

Although the primary participants were aware that the strategy-embedded developmental mathematics course differed from other developmental mathematics courses, they did not know exactly how and where the course differed. They did not realize that they were engaging in activities during the winter quarter that were any different from the activities of other conscientious college algebra students. They assumed that the secondary participants, for example, were “pretty much, like doing the same kind of stuff we all [were].” — Johnny. For all of these reasons, I believe the primary participants engaged in the activities that they reported because they thought these activities would facilitate their own learning and understanding, not because they felt I expected them to do so.

While the primary participants were familiar with and engaged in a variety of learning strategies, they were somewhat handicapped in the domain of self-monitoring. Data indicate that self-monitoring was difficult for all of the study participants. According to Lester (1994), the development of self-monitoring (metacognitive) skills in mathematical problem solving requires knowing what, when, and how to monitor. Most of the primary participants understood that they should be monitoring their understanding, but they struggled with the “what”s, “when”s, and “how”s of monitoring. They were still developing their skills in
this area. Unfortunately, they were no longer in an environment that fostered this type of development.

**Self-Reflection Phase**

In this section, students' self-reflective processes with respect to their performance in college algebra are revealed. Data address the following questions:

- What types of judgments (self-evaluations) do students make with respect to their academic efforts?
- To what do students attribute their successes and/or failures? and
- How do students use this information, if at all, to improve (adapt) their current situations?

Students' self-reflections and forethought processes tended to overlap. Their adaptations (based on self-reflections) often developed into new goals and new plans of action. Statements like, “I should have been doing more of the homework problems” (self-reflective accounts) became, for example, “I am going to start doing more homework before the next test” (new goals and plans).

**Self-Evaluations**

During the strategy-embedded developmental mathematics course, students were initially required to analyze and correct their examination errors. Many students continued to use this self-evaluative technique throughout their college algebra courses. Tad, Johnny, Donovan, Rachel, and Estelle always
corrected their exams. They even enjoyed discussing their analyses of their errors during our interviews.

*Tad:* “I missed the questions from the lectures I missed. As soon as I left the test I opened my book and found out how to do them. It wasn’t that hard.”

*Johnny:* “I missed this because I didn’t read the rest of the thing and didn’t get the range. Then I missed a negative there.”

*Donovan:* “I know exactly what I missed—I thought you couldn’t have a fraction there, but you can. Then I forgot how to bring y to the outside here—stupid mistakes.”

*Rachel:* “I made some arithmetic errors—like this minus sign. I also forgot to simplify some of the answers. And on this one, I could have factored this one more time, but I didn’t see it.”

*Estelle:* “I didn’t know that fractions could be eliminated from the domain. All our homework had only whole numbers. So I said the answer was ‘all real numbers’ but ¾ didn’t work.”

Not all the primary participants analyzed their examination errors. Jake said he simply did not have the time to go over his exams. His instructor “wrote the answers on the board, but he [the instructor] didn’t really have time to go over it.” Jake had briefly looked at his first exam and commented: “I tend to make the same mistakes over and over again.” Mary refused to even look at her exam.

Kelly was initially unwilling to show me her first test—she scored a 52%. “You made us go back and correct our tests and he [her college algebra instructor] doesn’t. Which I think is, well, I love when we had to go back and do our tests over because that showed me, ‘wow, that’s a stupid mistake, I’ll never do that again.’ But he [her college algebra instructor] just gave us our tests back
and said, ‘Any Questions?’ with like two minutes left in class and I haven’t
looked at mine since.” Kelly hesitated and then continued (perhaps influenced by
my line of questioning), “But I am going to take the time to go over my mistakes
this weekend.”

Kelly added, “Sometimes I know how to do something but then the
directions confuse me. I was overconfident on the first test. I took a nap right
before the test. I thought I knew everything. The first test was literally a wake
up call.”

After the second exam, four students (Kelly, Rachel, Donovan, and
Johnny) had very similar explanations for some of their errors.

Kelly: “The reason I think Test 2 was so hard is because the day of the
midterm was the first day we saw 6.4 and 6.5 and there were
problems about it on the test. That was hard because I didn’t have
time to understand it and I missed both of those.”

Rachel: “They kind of crammed in sections 6.4 and 6.5 and I missed
those.”

Johnny: “I knew for a fact after that test that I wasn’t going to get two of
them right—number 2 and number 10. Because like they were
assigned to us on Friday, okay, which was 6.4 and 6.5 and then
Tuesday was the test. And in recitation, we didn’t have time to go
over everything.”

The primary participants (Mary excluded) tended to react in positive ways
to their performances. For example,

Johnny: “All my friends said that the second test is the hard one. And I
was like, wow I did pretty good. I think I’m doing better than
most.”
Donovan: “I am disappointed in myself for my stupid mistakes, but I can’t get mad at myself because I am taking this class for the first time.”

None of the secondary participants analyzed their examination errors or spent much time at all reflecting on their performances. S2 and S4 reported that they did not like to look at their tests because it was too depressing. S1 was satisfied with his performance on the first two tests because he had scored above the medians on each. S4 felt that it was not fair that “they put stuff on the tests that we had just talked about.” S3 commented that, “they teach it like you already know it. Sometimes you try hard and you just don’t get it.” The overriding sentiment (S1 excluded) was, “If I performed poorly, it was because I was not taught well enough.”

Attributions

The primary participants (Mary excluded) attributed their failures to correctable causes and their successes to personal competence. According to Zimmerman (1998), this is one of the characteristic of self-regulated learners.

Tad: “I knew I was ready for the first test, and I was.”

Johnny: “I did everything I like should have for the first test and I got an 80—which was good...I messed up on my third test because I blew off the homework. I don’t think I practiced enough and put enough time into math. I didn’t feel like doing as much for the third exam. I’m not trying to blame anyone or anything, but I think I was just too lazy. I needed to sit down and relax. I think most of the stuff I don’t know is because I haven’t given myself time to learn it. If I had more practice, I would have known how to do it. I missed three lectures and I should have went to those. That’s the stuff I missed on the test. I’m not blaming the instructor for anything. I mean, you know, it’s totally my fault.”
Jake: “I'm taking 20 hours. I didn't know that taking 20 hours was so much. I know I could have done this math if I had more time.”

Donovan: “The instructor kept saying you have 30 minutes to finish, you have 20 minutes, you have 10 minutes, and I don't like that because it broke my concentration. I'm not blaming him though. I need to learn to ignore him—maybe get earplugs or something. I was disappointed with the first test because I made mistakes I shouldn't have. I knew how to do it, but I didn't take the time to check my work.”

Kelly: “I also had a sociology test the day after my college algebra test and that was tough—which one do I study for? Which one is going to be harder? I always put math to the side. After the math test, I knew I failed it. Well, that just shows me that I wasn't prepared for it, that I didn't take it seriously enough, I studied maybe too much for my sociology and I wasn't doing as much math as I should have. I mean math comes pretty easy to me if I take the time.”

Rachel: “On the first test I relaxed and didn't think too hard on each question. I would just piece it together. I would write down all my givens to get started. I think that's why I did so well...I don't like blaming it [grade on Test 2] on my lecturer or my recitation teacher. Me, personally spending more time is important. The blame I would put would be on myself. I should be giving more time to my math.”

Estelle: “I was pressed for time. I kept looking at my watch. They were walking around saying, you have 10 minutes left. I should have gone to those tutors. That would have helped me get faster at this.”

As far as Mary was concerned, her learning and performance were completely out of her control. Some of her attributive statements follow.

Mary: “The last two problems [on Test 1] were word problems and he [her instructor] didn't go over these in class. I failed developmental math the first time because I had a bad teacher and my teacher now is one of those people who makes mistake. That messes me up. I don't think he really knows how to teach.”
The secondary participants found it difficult to explain (attribute) their performances.

S1: “I just did what it took—went to class and did the required homework.”

S2: “I don’t think I’m dumb. I mean I work really hard but nothing seems to work for me except going to tutoring. I try my homework at home but I just can’t get it. I just do better with somebody sitting beside me.”

S3: “They [test writers] need to stop picking all the hard problems for the test and putting stuff that we just did on there too. I can do the problems but just not all the ones on the test.”

S4: “I don’t know why I can’t get this.”

S1 credited his own efforts for his relative success. S2 and S4 did not know who or what to blame and/or credit. S3, on the other hand, found the test writers to blame for her low achievement on the exams.

Adaptivity

The primary participants (Mary excluded) generated new goals and new plans of action after each college algebra exam. These goals and plans were based on the students’ self-evaluations and attributions. Many of these revised goals and plans have been discussed earlier in the chapter (see Forethought Phase, Performance Phase, and Figure 46). Some of the students’ proposed adaptations follow.

Tad: “Now that I can’t really go to class all the time, I need to focus on trying to learn some of the math, rather than all of it, or I won’t get any of it.”
Johnny: “I need to start checking over my tests before I turn them in.”

Jake: “I need to work on understanding and stop looking at the answers in the back of the book first. I know that doesn’t help.”

Donovan: “I change my approach to studying all the time trying to find the one that works right for me. I still need to do more practice. If I’m not happy with my grade [on Test 1], I’ll start doing more problems. I’ll go to the learning center too...I could have looked over the whole aspects of each chapter [for Test 2]—not just the lectures and the homework. Anything [6.4 and 6.5] is fair game.”

Kelly: “I need to find somebody to study with. My roommate is not a good person to study with because we have the same kinds of questions. We went over the 6.4 and 6.5 stuff in class today and I know how to do it now, so I won’t miss it on the final. I really have to bust my butt on the next test and the final. The final is worth almost 40% of the grade...For the second test I was spot checking my homework. Now I am going to start doing all of them. I need to study every night a little bit, do all the homework, and go to lecture more.”

Rachel: “Sometimes I look at the sections in the book before I go to class and if I know what’s going on then I just don’t go. But after this midterm, I’m going everyday.”

Estelle: “I need to start making time for the tutoring lab.”

Mary had no idea what she could be doing differently—after all, her success or failure was completely dependent on the instructor. I asked Mary if she had considered changing instructors. She replied, “No...[long pause]... I mean I guess I should.”

As previously stated, the secondary participants did not modify their plans of actions at any time during the first seven weeks of the quarter. S1 was happy with his performance and saw no need for modification. S2, S3, and S4 were doing everything they knew to do.
Summary

After reading an early draft of this chapter, a colleague commented that, “the secondary participants weren’t the greatest students.” This, however, is not the image I intended to present. These four students successfully completed a developmental mathematics course and enrolled in a college algebra course believing they would succeed. They attended their college algebra classes (both lectures and recitations) on a regular basis (an atypical behavior based on my observational data) and completed all the required homework assignments. They were doing exactly what their instructors had asked and expected.

Unfortunately, three of these students (S2, S3, and S4) were dissatisfied with their performances in college algebra and seemed unable to modify their actions. One student (S4) eventually dropped the course. Maybe this was not a representative group. I believe it was.

The secondary participants did not, for the most part, engage in self-reflective processes. They did not analyze their performances or consider new approaches to learning. They often blamed others for their mistakes or reported feelings of helplessness.

The primary participants, on the other hand, reflected on their experiences and used this knowledge to help them develop methods for improving their learning. They took a proactive stance: “I know what I should have done, now I’m going to do it.” Even if the students did not follow through on their plans, they gained a sense of control over their learning.
Summary

Data collected during the second phase of the current investigation were organized and analyzed using the lens of self-regulated learning theory. The three cyclical phases of self-regulation—forethought, performance, and self-reflection—were used to frame this discussion. With respect to the forethought phase, the primary participants (Mary excluded) set goals and devised plans of action throughout the winter quarter. Goals and plans were periodically modified and refined based on students' performances and self-reflective data. These behaviors have been found in the research literature to lead to positive achievement activities (Ames, 1992; Pintrich & Schunk, 1996).

The secondary participants' goals and actions, on the other hand, were closely tied to their course requirements. Research indicates that this is often the case (Ames, 1992). These students did not modify their plans during the course of this investigation, even when they were dissatisfied with their performances. While these participants began the quarter believing they were capable of success in college algebra (self-efficacious), they (S2, S3, and S4) grew increasingly discouraged as the term progressed.

The primary participants (Mary excluded) maintained a high sense of self-efficacy for learning college algebra content throughout the quarter. According to Bandura (1996), these beliefs serve to increase both students' efforts and achievements.
With respect to the **performance phase** of self-regulation, the primary participants (Mary excluded) engaged in a variety of different learning strategies during the winter quarter. Students had been introduced to many of these strategies during the strategy-embedded developmental mathematics course. They experimented with various approaches attempting to find the methods that “worked for them.”

The secondary participants used a limited number of strategies to approach learning in college algebra. Research on self-regulation in academic settings indicates that the “less frequent mention of strategies by students in the lower achievement tracks was not due to their lack of verbal expressiveness but rather to their lack of self-regulatory initiative” (Zimmerman, 1990a).

Self-monitoring, a performance-related activity, was difficult for all of the participants. According to Winne (1995),

research on comprehension monitoring describes three primary purposes for monitoring: (a) to recognize whether information has been comprehended; (b) to gauge the extent to which information comprehended has been learned; and (c) to characterize states of comprehension and learning so that, if goals are not met, the presence and perhaps nature of that discrepancy triggers remedial procedures for filling gaps or repairing errors. (pp. 178-179)

The primary participants used monitoring primarily for the purpose of filling in gaps and repairing errors. They needed more guidance on monitoring their learning and gauging their understanding as they studied.

The primary participants’ self-reflective processes were far superior to those of the secondary participants. The primary participants (Mary excluded)
used the knowledge they acquired during the self-reflective phase of self-regulated learning to develop new goals and devise new courses of action. Students continued to refine their approaches to studying and learning throughout the quarter as the cycles continued. The primary participants were becoming self-regulated, strategic learners.

Emergent Themes

As I compiled and analyzed the overwhelming quantity of data related to the current investigation, I discovered “piles” in my compilations that became increasingly thick. Trends, or themes emerged from these stacks of data. Three of these themes are discussed herein: responsibility, empowerment, and the big picture.

Responsibility

The primary participants (Mary excluded) took responsibility for their own learning in the college algebra course. They developed their own goals and plans of action that exceeded course requirements. They did not rely on others to initiate (require) productive behaviors. The primary participants also took responsibility for their own successes and failures. They did not credit others for their successes or blame others for their failures.

Empowerment

The primary participants (Mary excluded) took control of their learning. They engaged in a variety of learning strategies and made decisions regarding the
effectiveness of these strategies. They continuously modified and refined their approaches based on their own self-assessments. They never ran out of ideas for improving their learning. Although they were, at times, dissatisfied with their performances, they never expressed feelings of helplessness. They knew they were in control.

**The Big Picture**

Both the primary and the secondary participants lacked an understanding of the connectedness of the content in the college algebra course. They viewed topics and examples in isolation. As previously indicated, lectures supported this view.

Because students were unable to extract the main ideas of the course, study sessions were often misdirected. On the second exam, for example, students reported that they expected “a water problem instead of an airplane problem”—Jake. They saw this type of problem (the “water problem”) as one of the main ideas that had been discussed in the course. Examples had been presented in lecture and homework had been assigned related to this “topic.” According to Donovan, “I expected a still water problem like where you had to find the upstream/downstream speed and none of that was on the test.”

The question that did appear on the students’ exam as well an example of the type of question that the students’ expected to see on the exam, follows.

**Actual Exam Questions:** A plane made a round trip between two cities that are 630 miles apart. Flying against the wind took 2 and 1/3 hours,
but flying with the wind took 1 and 3/4 hours. What are the rate of the plane (in calm air) and the rate of the wind?

**Anticipated Exam Question:** A boat moving downstream can travel 10 miles in one hour with the current. A boat traveling upstream at the same rate can travel only 8 miles in one hour. What are the speed of the boat (in still water) and the rate of the stream?

In actuality, both the “water problem” and the “airplane problem” were applications of systems of linear equations (the main idea).

On the same exam, students also expected to see “a chemical solution problem or an investment problem and they [the test writers] didn’t have any of those on there”—Johnny. The main idea encompassing these types of problems was solving rational equations. One of the questions on the exam did address this topic.

Each time I asked the students to delineate the main ideas that had been covered in their college algebra courses, I heard the same types of responses. Students referred to specific examples rather than topics and main ideas. When examples are viewed as topics, the content of any course appears overwhelming. Students may spend too much time studying examples from one topic and then completely ignore another topic. They are often surprised by examination items because they are unable to make accurate predictions. They begin to view mathematics courses as disconnected and unsystematic.
CHAPTER 6

DISCUSSION

When large numbers of students fail and/or leave mathematical study, this is now judged to be the failure, not of the student, but of the educational system. (Bass, 1997, p. 18)

Revisiting the Research Questions

The current investigation examined underprepared college mathematics students' approaches to studying mathematics under two conditions. First, the investigation examined students' responses to a college developmental mathematics course in which mathematics-specific learning strategy instruction was purposefully embedded. Second, the investigation examined the approaches to studying mathematics employed by eight of the developmental mathematics students who had completed the strategy-embedded developmental mathematics course and were enrolled in a college-level mathematics course that did not include a learning-strategy component. Additional data regarding the original investigation participants can be found in Appendix D.
Results of Mathematics-Specific Learning Strategy Instruction

How do college students enrolled in a developmental mathematics course approach learning when mathematics-specific learning strategy instruction is embedded within the course? Throughout the 10-week strategy-embedded developmental mathematics course, students learned to take good notes during a lecture, read a mathematics text, and explore available resources. In addition, students engaged in activities that focused on setting goals, monitoring progress toward goals, and evaluating and revising plans of action. Test preparation and test-taking strategies were investigated throughout the term, and students learned to analyze and evaluate their examination errors.

As a result of strategy instruction, the developmental mathematics students came to realize that strategy use was effortful. For example, many of the students found it difficult to take good notes and challenging to read a mathematical text. Following recommendations by Pintrich (1995) and Schoenfeld (1992), students were given numerous opportunities to practice these (and other) self-regulatory learning strategies. As students gained experience in these strategic learning activities, performance became automatic. Students, for example, were eventually able to focus on mathematical content during a lecture rather than dividing attention among notetaking strategies and mathematics. Automaticity is necessary to facilitate transfer (Woolfolk, 1998). Research indicates that students are more likely to continue using learning strategies that require minimal cognitive attention (Weinstein, 1985).
Over the past 12 months, I have discussed this research project with mathematics faculty from six different colleges in three states (Ohio, Texas, New York). These educators were all surprised to learn that students lacked a basic knowledge of mathematics-specific learning strategies. They never considered, for example, the need to discuss reading in the content area or the use of available resources. They assumed students already possessed this knowledge (and perhaps chose not to engage in these activities). These faculty were amazed to learn that teaching mathematics-specific learning strategies required a considerable amount of classroom time and attention, and that students reported that strategy use was extremely effortful at first. Perhaps one of the most important outcomes of the current investigation is the revelation that students do need instruction on studying and learning, and they may initially find these activities to be difficult.

As the quarter progressed, students began to take responsibility for their own successes and failures. They did this by reflecting on their experiences and attributing course-related outcomes to actions rather than abilities. The students were able to make these attributions because they were aware of a variety of mathematics-specific learning strategies (actions) that might be used to affect their performances. If they were dissatisfied with an examination score, for example, they were capable of analyzing and modifying their approaches to studying and learning based on options discussed throughout the strategy-embedded course. According to Hagen and Weinstein (1995),
The more students can take responsibility for their own learning, the more likely they are to attribute success to their own efforts. If students believe that their efforts will make a difference in what and how much they learn, then they are more likely to expend higher levels of effort in their studies. (p. 53)

Students who believe that outcomes are contingent on behaviors have higher expectations for success and are more persistent (Pintrich, 1994). The developmental mathematics students, as a result of strategy instruction, believed that they were able to control their learning and studying experiences.

This growing sense of control exhibited by the developmental mathematics students served to increase the students’ self-efficacy for learning mathematics. Students began to believe that they could successfully approach studying and learning. At the beginning of the developmental mathematics course, most students strongly disagreed with the statement: I know how to study mathematics. By the end of the term, no one disagreed with this statement. Similarly, at the beginning of the course, only five students agreed with the statement: When a mathematics problem is difficult, I can learn how to do it. By the end of the course, 14 students reported strongly agreeing with this statement, and no one disagreed.

According to Snow, Corno, and Jackson (1996), “the sense of self-efficacy is hypothesized to affect individuals’ activity choices, effort, and persistence” (p. 277). Because the developmental mathematics students believed they were capable of succeeding in mathematics, they engaged in effortful activities (learning strategies) throughout the 10-week course—even when the
activities were no longer required. If learning strategies were deemed ineffective by the students ("My approach to doing homework is not working."), then modifications were planned, but self-efficacy was not lowered ("I know I can succeed in the future if I just start doing all the homework.").

Self-efficacy is related to self-concept in academic settings (Snow, et al., 1996). Self-concept has been studied as a descriptive, cognitive construct ("I am good at mathematics") and as an evaluative, affective construct encompassing both self-esteem and self-worth ("I feel good about how I do mathematics"). On the cognitive side, the developmental mathematics students initially believed that they were not good at mathematics. By the end of the strategy-embedded developmental mathematics course, sentiments had changed to either, "I guess I'm okay at this stuff" or "I can't believe I'm saying this, but I think I am good at math." High self-concept has been shown to be related to increased achievement in classroom settings where instructional support is low (Snow, et al., 1996). This finding may be particularly meaningful for the study population because the typical post-secondary mathematics instructor offers minimal teacher supports.

The strategy-embedded developmental mathematics course offered multiple supports in the form of study skills training, psychological support, and grade-related rewards (students received credit for completing strategy-related assignments/activities). Although the demands of college-level mathematics courses are not notably more difficult than the demands of the strategy-embedded developmental mathematics course, significant differences in terms of supports
existed. These differences were made explicit throughout the strategy-embedded course. According to Woolfolk (1998):

"Years of research and experience show that teachers cannot expect students to automatically transfer what they learn to new problems. Students will master new knowledge, problem-solving procedures, and learning strategies, but not use them unless prompted or guided. (p. 321)"

For this reason, transfer of strategy use was often discussed during the developmental mathematics course. Students were encouraged to reflect on their activities and modify their behaviors as necessary—to personalize the process. If the participants were engaging in mathematics-specific learning strategies solely for the purpose of meeting course requirements, then the students would discontinue these behaviors when requirements were removed. To facilitate transfer, the strategy-related requirements of the developmental mathematics course were decreased as the term progressed.

Knowing what to do and doing what you know, however, are two different things. I believe that the students left the strategy-embedded developmental mathematics course with the knowledge of a variety of learning strategies. I was concerned, however, that the students would not continue to use these strategies—not for reasons of transfer, but as a result of choice behaviors.

Throughout the developmental mathematics course, time management struggles were often reflected in students' choices with respect to studying and learning mathematics. The students frequently revealed that they knew what to do, but did not have adequate time to engage in these activities. The participants, many
of whom were first quarter freshmen, were still in the process of adjusting to the increased demands of college life. Scores on the Learning and Study Strategies Inventory (LASSI) indicated that the majority of students struggled with time management (TMT).

**Participants’ Approaches to Learning in Subsequent Courses**

*How do students who were enrolled in a strategy-embedded developmental mathematics course approach learning in their first college-credit mathematics course if strategy instruction is no longer a course component?*  
Most of the students who had enrolled in the strategy-embedded developmental mathematics course continued to engage in strategic learning activities in their subsequent mathematics courses. They developed course-specific goals and plans of action. Participants’ performance activities included many of the strategies explored during the developmental mathematics course. Students reflected on the outcomes of their efforts and modified their goals and plans as needed. They typically had ideas for improving their learning (although some of their ideas never emerged as actions). Students continued to attribute their successes and failures to actions rather than abilities. They were exhibiting many of the characteristics of self-regulated learners.

Unfortunately, the students continued to struggle with time-management issues. Students’ plans often exceeded their actions. They did, however, continue to take responsibility for their own choices with respect to time management.
The (primary) participants’ approaches to studying and learning were found to be very different from the approaches used by the four secondary participants—students who had not enrolled in the strategy-embedded developmental mathematics course. The secondary participants had no stated goals or plans, did not engage in performance-related activities that exceeded course requirements, and lacked the ability to reflect on and modify their course-related actions.

*What strategies do students chose to employ?* The primary participants reported studying their lecture notes, reading their textbooks, and using tutoring facilities and other resources. They also engaged in a variety of test preparation strategies, group study sessions, and error analysis activities. All of these strategies exceeded course requirements and recommendation.

The secondary participants, on the other hand, merely completed the required homework assignments and attended class meetings. They were unable to develop plans that included additional activities or resources. As a result, these students often did not perceive a contingency between their actions and course-related outcomes (low examination scores, for example). They expressed thoughts such as: “I don’t know what else I could have done—I did everything I was supposed to do.” (see Pintrich, 1994, for a discussion of learned helplessness). Unlike the primary participants, these students exhibited a lack of control with respect to their learning, understanding, and performance in mathematics.

*Why were particular strategies selected?* As previously stated, the strategies used by the secondary participants were selected because they were tied to course
requirements. The primary participants reported using strategies they had learned during the strategy-embedded developmental course. They continued to use the strategies that they perceived to be useful and time-effective.

What factors facilitate or impede the use of learning strategies? Some of the compensations associated with the college algebra course decreased students' use of learning strategies. For example, whereas students analyzed and corrected their examination errors during their enrollment in the strategy-embedded developmental mathematics course, most often their college algebra instructors supplied examination corrections. In doing so, opportunities for learning, self-evaluation, and self-reflection were lost.

A change in course demands may have also impacted the students' approaches to studying and learning in college algebra. In the developmental mathematics course, homework assignments were not divided into categories (recommended and required) as they were in the college algebra course. All homework in developmental mathematics was required homework. The amount of required homework in college algebra (assignments that were to be turned in for a grade) was minimal—typically two or three problems per topic.

These assignments were purposefully kept small because class sizes in college algebra were much larger than class sizes in developmental mathematics and grading more than two or three problems would have been impossible. This practical motivation for minimizing required homework, however, was not made clear to the students. The students believed that if they could complete the required
homework problems, then they understood the topic. Additional problems (the recommended assignments) were to be completed only if difficulties arose with the required homework. Although instructors believed that they had made it clear to the students that both required and recommended homework assignments should be completed, students' perceptions indicated otherwise. The primary participants often completed both the required and the recommended assignments. However, they believed that they were going above and beyond the demands of the course.

The primary participants also found it difficult to identify main ideas and to understand the relationship between the topics in college algebra. Specific examples were often seen as topics and were studied as such. Instruction did not explicitly focus on connections among these topics or on the hierarchical relationship between topics and examples. As a result, predicting examination items was particularly challenging for these students.

**Summary**

As a result of instruction in the strategy-embedded developmental mathematics course, students: (a) reported feeling less teacher driven; (b) took responsibility for their own successes and failures; (c) attributed failures to actions rather than abilities; (d) became familiar with a variety of mathematics resources; (e) made decisions about when and why to use these resources; (f) learned to reflect on the outcomes of their decisions; and (g) gained a sense of control over their mathematical experiences.
The students who enrolled in the strategy-embedded course continued to benefit from this instruction throughout their enrollment in college algebra. Overall, the students who had participated in the strategy-embedded developmental mathematics course: (a) continued to use mathematics-specific learning strategies; (b) took responsibility for their own successes and failures; and (c) took control of their own learning during the college algebra course.

Additionally, data indicated that both the primary and the secondary participants found it difficult to identify main ideas in the college-level mathematics course. Topics and examples were often viewed in isolation. This may serve to explain why students found it difficult to focus their test-preparation efforts.

Research into Practice

The results of this investigation indicate that: (a) many underprepared college students do not know how to approach studying and learning in mathematics; (b) college mathematics classrooms typically do little to help students direct their own learning; (c) mathematics-specific learning strategy instruction can be embedded within a content course; and (d) students benefit from strategy instruction. If the results of this investigation are to have an impact on classroom practice, then the needs of postsecondary mathematics faculty and the responsibilities of the researcher must be considered.

First, what do faculty want? Faculty typically do not want calls for additional research on student learning or recommendations for radical change
regarding teaching and learning (Schoenfeld, 1991). What they do want are materials in a “ready-to-wear” format. Schoenfeld (1991) states:

Simply put, the perspective of the mathematical community is this: We know how to teach, and can do it well if we devote the time and energy to it. (It’s a shame we’re as busy as we are and can’t spend as much time grading assignments, etc.) What we need is for people to give us the resources that make things easier—means of keeping current and good classroom materials, ready for use. (p. 271)

Schoenfeld goes on to state that mathematics faculty neither want nor need the details of research investigations. They are merely looking for resources that are immediately useful.

*What are the responsibilities of the researcher?* According to Schoenfeld (1991), “For the most part [mathematics education researchers] tend to leave the development [of educational curricula] to others: Having worked out the ideas, they hope to see them implemented but do not take that implementation as a primary responsibility. Whether anyone will ever follow up on any given research finding is problematic” (p. 267).

If the findings of this investigation are to have an impact on practice then *I* must:

- present these findings with a focus on implementation;
- publish my work in journals that are read by the user community (undergraduate mathematics faculty); and
- create and disperse resources for immediate use.

These are my current goals with respect to this project.
Future Research

Throughout the current investigation, possible avenues for future research continuously emerged. The following is a selection of topics and questions that need to be addressed.

- How do students’ and teachers’ perceptions of mathematical content (as presented in a lecture) differ? This might be addressed by asking instructors and students to first summarize the main ideas of a lecture and then compare these summaries.

- What assumptions do mathematics faculty make with respect to students’ knowledge and use of mathematics-specific learning strategies? What do instructors assume students already know how to do?

- Are there differences between what instructors believe they have made explicit during instruction and related student knowledge? If so, why?

All of these questions emphasize mathematics faculty beliefs and perceptions. Research and recommendations that focus on improving the experiences of postsecondary mathematics students through instructional interventions—like the current investigation—must ultimately be sensitive to the beliefs and perceptions of the user community.
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APPENDIX A:

A Review of Literature

The following pages contain a review of the research literature related to student achievement at the college developmental mathematics level as well as literature related to the acquisition and teaching of learning strategies. Portions of this paper were references/discussed in the body of this dissertation.
REVIEW OF RELATED LITERATURE

Introduction

In this paper, I review the research literature associated with enhanced performance in college-level developmental mathematics. I begin with a general review of research on achievement. This leads to an extended investigation of the benefits of supplemental instruction for remedial students. The review then broadens to include non-mathematics specific research literature related to learning strategy instruction. The paper concludes with the development of the specific research questions that will be addressed in the proposed study.

The writing in this paper is guided by a fishing metaphor because in many ways preparing a literature review is like going on a fishing expedition. My site selection (library database) and choice of bait (keywords), for example, were continually modified in an attempt to increase my catch (relevant research articles). Additionally, I began to learn which fish (articles) to keep and which to throw back based on my own personal tastes as well as my ability to consume.

At the heart of this search is my desire to improve the experiences of college-level developmental mathematics students by increasing the likelihood of their successes both during developmental instruction and in subsequent college-level mathematics courses. I proceed with the following assumptions: (a) Remedial courses that focus solely on mathematical skill development offer incomplete
solutions; (b) Developmental mathematics courses must be designed to promote student success in college-level mathematics courses; and (c) Most learning in college occurs outside the classroom.

Much of the research on achievement in college developmental mathematics has focused on factors that promote within-course success (i.e. small class size, frequent testing). These factors are often external to the learner, and may or may not enhance achievement in subsequent college-level mathematics courses.

In my search for student-centered investigations, I was drawn to studies that focused on developing self-regulated, strategic learners. According to Pintrich and Schunk (1996):

**Self-regulation** is the process whereby students activate and sustain cognitions, behaviors and affects that are systematically oriented toward attainment of their goals. Students motivated to attain a goal engage in self-regulated activities they believe will help them (i.e. rehearse material to be learned, clarify unclear information). In turn, self-regulation promotes learning, and the perception of greater competence sustains motivation and self-regulation to attain new goals. (p. 182)

Many of the articles reviewed in this paper focus on students' use of self-regulatory activities. According to Pintrich (1995): "Teachers can teach in ways that help students become self-regulated learners" (p. 9). Pintrich offers several recommendations for promoting student self-regulation: (a) Students must become aware of their task-specific behaviors, motivations, and cognitions; (b) Faculty must adopt models of instruction that include self-regulated learning components; and (c) Students must practice self-regulated learning strategies.

**Where are the Fisher(wo)men?**

In this section, I explore two preliminary questions. First, is there a need for research on improving achievement in college developmental mathematics? And
second, if student achievement in college developmental mathematics is as low as statistics suggest, then why is the research base so limited? (Note: Information regarding the limitations of the research base is found elsewhere in this paper.)

**The Needs Are Clear**

Many students begin their postsecondary education with an inadequate foundation in basic mathematics. The American Mathematical Association of Two-Year Colleges (AMATYC) (1995) reported that, in 1990, fifty-six percent of all students studying in two-year college mathematics departments were enrolled in remedial-level courses. AMATYC also reported that approximately fifteen percent of all mathematics students attending four-year colleges and universities were enrolled in pre-algebra mathematics. Nationwide figures suggest that 1.1 million college students are currently studying mathematics at the remedial level (AMATYC, 1995).

Student achievement in developmental mathematics is vital to any mathematics program (AMATYC, 1995). Upon satisfactory completion of some type of developmental mathematics sequence, students register for traditional mathematics courses. Hence, successful remediation programs are necessary in order to sustain enrollment in college-level mathematics courses.

Low student achievement in developmental mathematics courses at the postsecondary level is a growing concern for college and university mathematics departments. Although the percentage of students placed in remediation has remained relatively stable over the past six years, college enrollment has increased. Increased enrollment at the developmental mathematics level, however, has not resulted in increased enrollment in college-level mathematics courses (Albers, Loftsgaarden, Rung, & Watkins, 1992).
A Limited Research Base

The research base on student achievement in developmental mathematics at the postsecondary level is not as expansive as one might expect. Several factors may contribute to this deficit. For instance, the vast majority of developmental mathematics courses are taught by community college faculty. Teaching, rather than research, is of primary interest in these institutions. Additionally, developmental courses are often assigned to part-time instructors or graduate students (Crossroads, 1995). University mathematics faculty rarely teach developmental courses (Crossroads, 1995), are typically not interested in instructional research (Bass, 1997), and have even been known to speak out against university-supported remedial programs (Mityagin, 1996).

Many of the teachers who are "down in the trenches", working diligently to improve the experiences of developmental mathematics students, have neither the time nor the inclination to publish formal reports detailing their efforts. Partnerships between researchers and experienced developmental mathematics instructors are needed. Emergent theories of learning that view teaching as an integral component in any model of learning (Cobb, Wood, & Yackel, 1990; Davis, 1996; Hatano, 1996; Hodge, Ouztz-Simpson, & Preston-Sabon, 1993) may serve to increase the likelihood of such partnerships.

Finding the Right Bait

In the previous section, I have suggested that the research base on student achievement in college developmental mathematics is limited. The information in this section can be used to substantiate that claim. Two distinct literature reviews are found herein. The first review provides a broad survey of the research literature related to college developmental mathematics. The second review focuses on research efforts aimed at promoting student achievement.
Gone Fishin' 

During the fall of 1995, a preliminary literature search on achievement in developmental mathematics was conducted. Using the ERIC, Psychological Abstracts, and Dissertation Abstracts databases, I searched for articles under the keywords: any of the index terms college, university, postsecondary crossed with any of the index terms remedial mathematics, developmental mathematics, remedial math, developmental math crossed with any of the index terms achievement, success. Some of the items returned by the search were "thrown back" (for example: articles focussing on disabled or mentally handicapped students). The remaining articles were selected for inclusion in the preliminary review (Smith, 1996a).

The selected articles were qualitatively analyzed and thematically coded. The following categories were established: learner affect, student achievement predictors, testing strategies, instructional technologies, and environmental factors (Smith, 1996a). A summary of findings in each category follows (see Smith, 1996a, for the complete review).

**Learner affect.** Two of the performance-related affective variables (Reyes, 1984) that have been studied in the context of college developmental mathematics are academic self-concept and student motivation (Abramson, Seligman, & Teasdale, 1978; Tobias, 1991; Sowa & Burks, 1983). Most of this research has focused on alleviating the attributes and attitudes of learned helplessness as a way of improving mathematical performance. Sowa and Burks (1983), for example, found that by teaching a student to rephrase self-defeating statements concerning her/his mathematical ability, the condition of learned helplessness could be ameliorated. This would, in turn, result in increased achievement.

The affective variable that has received the most attention in the domain of mathematics, however, is mathematics anxiety (Dwinell & Higbee, 1991; Fennema
& Sherman, 1976; Ferguson, 1986; Tobias, 1991; Trent & Fournet, 1987). Research findings indicate that the relationship between achievement and anxiety among developmental mathematics students is yet unclear. While Dwinell and Higbee (1991) found that mathematics anxiety contributed significantly to the variance in final course grades for developmental mathematics students, Trent and Fournet (1987) warned that attempts to alter mathematics anxiety levels among developmental mathematics students, although successful in reducing the affective arousal associated with mathematical situations, have often failed to alter performance or improve grades.

Student achievement predictors. College and university mathematics departments use a variety of instruments as placement tools and predictors of success. The most commonly used instruments are the Scholastic Aptitude Test--Mathematics (SAT--M) (Educational Testing Service), the Descriptive Tests of Mathematics Skills (DTMS) (Educational Testing Service, 1979), and high school grade point average. Many researchers have attempted to validate these measures (Bridgeman, 1982; Ervin, Hogrebe, Dwinell, & Newman, 1984; Reilly, 1974). Ervin et al. (1984) found that developmental mathematics achievement was not related to any of the three predictor variables. These results were consistent with the findings of Bridgeman (1982). The researchers hypothesized that developmental studies courses may act as intervention and treatment programs. Hence, low predictor scores would not necessarily imply low achievement.

Testing strategies. The effects on achievement of examination frequency and repeated testing have also been studied at the developmental mathematics level (Chang, 1985; Gaynor & Millham, 1976; Glucksman, 1973; Martinez & Martinez, 1992; Rohm, Sparzo, & Bennet, 1986). Not surprisingly, research findings suggest that students' examination scores increase as the frequency of examinations increases (Gaynor & Millham, 1976). Gaynor and Millham (1976), for example,
found that developmental mathematics students who were tested weekly earned significantly higher grades than those students who received only a midterm and a final.

Research findings in the area of repeated testing are mixed. While some researchers indicated that repeated testing led to significantly greater student achievement in developmental mathematics (Chang, 1985; Martinez & Martinez, 1992), others found no justification for the use of retesting with developmental mathematics students (Glucksman, 1973).

**Instructional technologies.** In one of the more interesting studies on technology use in a developmental mathematics classroom, MacGregor, Shapiro, and Niemiec (1988) investigated the effects of computer-assisted instruction on achievement for developmental mathematics students with differing cognitive styles. The Group Embedded Figures Test (Witkin, Oltman, Rashkin, Karp, 1971) was administered as a measure of cognitive style (field-independence, field-dependence).

The researchers found that field-dependent students exhibited greater mathematical achievement when placed in a computer-augmented environment. Results of an attitude assessment also indicated that students in the computer-augmented course, regardless of cognitive style, had more positive attitudes toward both instruction and mathematics (see also Kulik, Kulik, & Cohen, 1980; Skinner, 1988).

**Environmental factors.** Class size and class structure are two of the variables considered by colleges and universities when courses are designed. Research indicates that developmental mathematics students prefer small classes (Freigenbaum & Friend, 1992). There is also evidence suggesting that smaller classes may lead to higher grade point averages and higher graduation rates for underprepared students (Clark & Halpern, 1989, McMillon, 1994). Dees (1991) found that a cooperative learning environment, in addition to small class size, contributed significantly to student achievement in a remedial mathematics course
(see also Billson & Tiberius, 1991; Burton, 1987; Chang, 1997a, 1977b; Key, 1992; Myers, 1996; Treisman, 1983).

**Catch of the day.** This preliminary literature review was my way of "testing the waters." I had explored the question, "What's out there?" In doing so, I learned that achievement in college developmental mathematics can be enhanced, according to the literature, by increasing the frequency of examinations or decreasing class size. Each of these methods, however, lies outside the students' realm of control. I was ready to continue my quest. This time, I would attempt to answer the question, "What more can be done?"

**Deep Sea Fishin'**

During the summer of 1997, a new computer search was conducted. Using the ERIC, Psychological Abstracts, and Dissertation Abstracts databases, I searched for articles under the new keywords: any of the index terms college, university, postsecondary crossed with any of the index terms remedial mathematics, developmental mathematics, remedial math, developmental math crossed with any of the index terms study skills, learning strategies, learning. A review of this literature follows.

**Mathematics lab.** Petricig (1988) studied the effects of mathematics lab attendance on mathematical achievement. A randomly selected group of developmental mathematics students (n=435) was required to attend weekly, individualized mathematics lab sessions in addition to their lecture-style intermediate algebra courses. Lab supervisors graded students' homework, answered questions, and supplied weekly written reports to students' course instructors indicating which students had satisfactorily completed their homework assignments. Students who neglected to turn in two homework assignments during a semester automatically failed the course.
Study participants' final course grades were compared to the final course grades of 399 students who had also enrolled in an intermediate algebra course but did not attend the mathematics lab. The researchers found that the students who participated in the lab experiment were more likely to pass intermediate algebra on their first attempt. Follow-up data indicated that participation in the mathematics lab was related to higher course grades, lower attrition rates, and increased success in subsequent college-level mathematics courses (Petricig, 1988).

**Learning support co-courses.** In an attempt to extend the mathematics lab model, Stratton (1996) initiated a Learning Support co-course that was paired with a simultaneously running college algebra course. Co-course enrollment was based on student self-selection. The volunteer population \( n = 80 \) consisted of former developmental mathematics students as well as students who had previously failed college algebra. It was hypothesized that co-course participation would result in increased achievement in college algebra, decreased mathematics anxiety, and improved attitudes toward mathematics.

Co-course instruction emphasized the processes of learning mathematics. Students were introduced to basic academic study skills, participated in group discussions on how to study mathematics, and engaged in a variety of activities focused on developing mathematics-specific learning strategies. For example, before each college algebra exam students predicted test questions and discussed test-taking strategies. Students also used the co-course to clarify their lecture notes and get advice on how to start mathematics problems.

Both qualitative and quantitative methods were used to evaluate the data. The final course grades of the study participants were compared to the final course grades of the students who enrolled in college algebra but did not attend the co-course (control group). Of the co-course students who completed the term, 100% passed the college algebra course. Only 79% of the members of the control group
who completed the course received passing grades. A grade comparison revealed that co-course students scored, on the average, seven percentage points higher than did the control group students.

Students' responses on a post-instruction mathematics attitudes questionnaire indicated that co-course participation helped students decrease their mathematics anxiety and improve their self-efficacy for doing mathematics. Responses also revealed that students were continuing to use the strategies they had been taught in the co-course.

**Supplemental instruction instead of remediation.** In a recent investigation conducted at the Ohio State University (OSU), Watson (1996) considered the effects of participation in a supplemental college algebra course on students' concurrent and subsequent achievement in college-level mathematics. Invitations to participate in the project were extended to all New First Quarter Freshmen (NFQF) who, (a) had taken at least three units of college preparatory mathematics in high school, and (b) were placed into a remedial-level mathematics course at OSU. A sample of 64 underprepared college students volunteered to participate in the project. These students were required to enroll in both college algebra (a non-remedial course) and the project course.

While in the supplemental course, project participants worked in small groups on worksheets containing probing questions related to mathematical concepts. During one session, for example, students were asked to verbalize the steps required for solving a series of literal equations for specified variables (ex: \( F = ma \), solve for \( m \)). The teaching assistant in charge of the supplemental course practiced the Socratic method for asking probing questions and encouraging students' interactions.

Three comparison groups were identified by Watson (1996). Achievement data from the treatment group were compared to achievement data from: (a)
students who were not eligible for the project and received traditional remediation (i.e. students with less than 3 units of college preparatory mathematics in high school); (b) students who were eligible for the project, elected not to participate, and enrolled in a traditional remedial mathematics course; and (c) non-remedial college algebra students.

While the non-remedial students received the highest average test scores and course grades in college algebra, Watson (1996) found that the project participants outperformed the other two comparison groups. Qualitative data suggested that the study participants worked harder and studied more than the members of the other three groups. Based on additional qualitative and quantitative data, Watson (1996) found that, "students in the treatment group stayed in school longer, took more subsequent mathematics courses, and had higher success rates in subsequent courses" (p. iii).

**Supplemental Instruction.** The Supplemental Instruction (SI) model, when carefully implemented, is recognized as a viable way of helping students succeed in mathematics courses (Burmeister, Carter, Hockenberger, Kenney, McLaren, & Nice, 1994; Kenney & Kallison, 1994; see also Kenney, 1989 for a review of early research related to Supplemental Instruction and mathematics). Two key features of this model are: (1) Supplemental Instruction is tied to a particular mathematics course, and (2) SI sessions are active and collaborative learning experiences.

Kenney (1989) investigated the effects of Supplemental Instruction on student performance in a first-semester business calculus course at the University of Texas. Typically, 30% of the students enrolled in this course received grades of D, F, or W (withdrew). The business calculus course was taught using a large lecture format with smaller discussion groups (recitations). Recitation attendance was required. For the purpose of this study, Kenney modified two of the recitation sessions to serve as Supplemental Instruction sessions. Kenney served as the SI
leader for the two modified sessions as well as the discussion group leader for two of the regular recitation sessions (control group).

In addition to the duties performed by typical discussion group leaders (attending course lectures, assisting students during office hours, grading papers, and answering homework questions), Kenney, in her role as SI leader, provided instruction on study skills relevant to the business calculus course. Students participating in the Supplemental Instruction sessions worked collaboratively on practice tests, reviewed test-taking strategies before each exam, and received note-taking instruction. Using a variety of statistical techniques, Kenney (1989) found that business calculus students who participated in the Supplemental Instruction group earned significantly higher final course grades and semester grade point averages when compared to the control group.

In a follow-up study, Kenney (1990) investigated the course-taking patterns and subsequent mathematics grades of the students from the original study. No Supplemental Instruction was available to students enrolled in second-semester business calculus. Statistical analysis revealed no significant difference in course grades between the two groups (SI and control), and no significant difference in mathematics course-taking patterns. The researcher conjectured that because Supplemental Instruction, by construction, is tied to a specific course/instructor, the benefits of participation are nontransferable.

Because there was some concern that the potential threat of experimenter bias had limited the aforementioned studies, Kenney and Kallison (1994) designed a new series of related investigations. One of the studies was conducted in a business calculus course (similar to Kenney, 1989). A second study investigated the effects of Supplemental Instruction on student performance in an engineering calculus course. Two mathematics graduate students were selected and trained as Supplemental Instruction leaders. The preservice training included an overview of
the general principles of Supplemental Instruction, information on pedagogical techniques for integrating content and SI instruction, and recommendations for teaching study skills. Extreme care was taken to assure that the comparison groups (SI and non-SI) were equivalent with respect to mathematical ability, mathematical achievement, gender, and ethnicity. Results from these two studies indicated that Supplemental Instruction "appeared to help the lower-ability students disproportionately more than the higher ability student" (Kenney & Kalison, 1994, p. 80). Although Kenney and Kalison (1994) recommend using an SI model to enhance student achievement in freshmen and sophomore level mathematics courses, they recognize that implementation of such a model requires careful consideration. Kenney (1989) warns that, "adding an SI dimension to [any course] would create the need for a different type of training for the persons leading these [courses]" (p. 27).

Supplemental Instruction leaders must be aware of the content that is being emphasized during the students' mathematics lecture, know how to use the course textbook as a resource, and recognize where students are likely to have difficulties (Burmeister, et al., 1994). Additionally, SI leaders are often challenged to plan activities that require students to struggle with course content and clarify their mathematical thinking.

Supplemental Instruction leaders. In an attempt to investigate the characteristics of an effective SI leader, a group of SI supervisors (Burmeister et al., 1994) observed and analyzed "successful" SI sessions for college algebra and calculus. A session was deemed successful if the students in the session asked questions, took risks, and worked actively and collaboratively toward understanding the mathematics. The leaders of these sessions were observed initiating a variety of active learning strategies. For example, successful SI leaders used probing questions, sorted concepts into matrices, and initiated informal quizzes. Successful SI leaders were also well prepared for each session. Lessons, activities, and
explorations related to the current lecture topic were created and implemented by these leaders (see Burmeister et al., 1994, pp. 55-59, for a series of vignettes based on their observations).

**Writing to learn.** Grossman, Smith, and Miller (1993) examined the relationship between the ability to write about mathematical concepts and the achievement of developmental mathematics students. Seventy developmental mathematics students at Georgia State University participated in the study. Each of these students had scored below 450 on the SAT--M and/or below 75% on a locally developed placement exam. An intermediate algebra textbook that contained one to five writing questions about the mathematical concepts in each section was selected to augment the traditional lecture-style remedial mathematics course. Additional writing assignments were created by the researchers and used as homework and in-class quizzes (see Tomlinson, 1990, for helpful principles on designing writing assignments that foster learning).

The students took four exams during a 10-week period. Each exam included, among other things, a single writing question and one or two mathematics problems directly related to the writing question. One of the writing questions, for example, was: "Use complete sentences to explain one advantage and one disadvantage of the quadratic formula method of solving quadratic equations" (Grossman, Smith, Miller, 1993, p. 3).

Statistical analysis was used to compare scores on the writing portions of the exams with scores on related computational problems. Using a Pearson coefficient, the researchers found the correlation between students' ability to write mathematically and students' computational skills to be .67 (p < .001). The relationship between mathematical writing and final course grade was also calculated. The resultant correlation was .79 (p < .001). The researchers
concluded that there is a strong relationship between the ability to write about mathematical concepts and mathematical achievement.

**Strategy instruction.** Hodge, Ouzts-Simpson, and Preston-Sabin (1993) used note-taking instruction, collaborative learning activities, and textbook reading strategies with their developmental mathematics classes in an attempt to "put the power of learning into the students' hands" (p. 13). Students were first taught to use a modified version of the Cornell Method of notetaking. Lecture notes intentionally modeled this format. Students were then instructed to transfer important information (i.e. formulas, sample problems) from their notes to notecards. Students were encouraged to shuffle the cards and practice the problems in random order.

Reading a mathematics book is often difficult for students. Hodge, Ouzts-Simpson, and Preston-Sabin (1993) taught their students to read mathematical texts by first skimming the material, then reading the entire section at a rapid rate, and finally, carefully rereading the section with pencil in hand (see also Johnson, 1984). The researchers found that students did read their texts when they were specifically instructed to do so. As a result of the strategy instruction provided in these developmental mathematics classes, the researchers reported that their students "expressed strong feelings of being in control of their learning. They felt less 'teacher' driven, more personally motivated, and in charge of their mathematics education" (Hodge, Ouzts-Simpson, & Preston-Sabin, 1993, p. 21).

**Study skills course.** Waycaster (1993) observed that regular study skills courses contained little or no information on how to adapt study techniques for courses like mathematics. In an attempt to fill this void, she created a new course, a Math Study Skills course. During the fall of 1991, 19 students enrolled in the new course. Six of the 19 students were simultaneously enrolled in a developmental
mathematics course. The Math Study Skills course topics included:

* Why do we need a Math Study Skills course?
* Attitudes toward mathematics classes
* How to prepare for the first day of class
* What to do during the class
* How to study and learn mathematics
* How to prepare for and take a mathematics test
* How to choose and use a calculator (Waycaster, 1993, p. 22)

In addition to the aforementioned topics, five mathematical content sessions were taught. These sessions focused on operations with fractions and word problems--two topics known to be difficult for developmental mathematics students.

Waycaster reported that of the six students who were concurrently enrolled in a developmental mathematics course, three passed with a grade of C or better, and three withdrew--a 50% success rate. During the spring of 1992, thirteen of the students who had taken the Math Study Skills course enrolled in a mathematics course. Four students passed the course, one student failed, and eight withdrew--a 30% success rate. The researcher concluded that "study skills must be taught simultaneously with mathematics content for maximum learning to be achieved" (p. 21). The researcher went on to suggest that study skills training should be introduced to students as early as possible in their academic careers, and that study skills activities must be linked to graded projects or incorporated into tests.

An Unexpected Catch

Winne (1995a), in an attempt to understand how learners develop and use self-regulated learning (SRL) when they study alone, designed a qualitative observational study. This investigation was motivated by the researcher's assumption that "learning effectively by oneself will [continue to] remain a goal of education" (p. 173). The subject of Winne's study was Pat, a 4th-year honors
psychology student enrolled in an advanced seminar on formal mathematical models. Winne describes Pat as a "cognitively well-prepared and self-regulated learner who thirsts for knowledge" (p. 174). Pat was observed by the researcher as she attempted to read, study, and understand a particularly challenging topic in preparation for an upcoming presentation.

Winne (1995a) found that Pat’s approach to studying displayed three salient features. First, Pat was aware of factors that may impede learning, such as loss of focus or diminished attention. Second, Pat consistently selected goal-directed study tactics. For example, when faced with a difficult textbook problem, Pat first attempted to understand the question by defining each term; she then developed a concept map to represent the problem; and finally, she annotated each concept. According to Winne, the third feature of Pat’s approach to studying can be characterized as affective and cognitive control. Although Pat was nervous about her presentation, she used her emotions to motivate adequate preparation rather than to impede progress.

**Summary**

Whereas my preliminary literature review (Gone Fishin’) revealed the breadth of research on achievement in college developmental mathematics, my subsequent review (Deep Sea Fishin’) contained in-depth information on instructional activities that were shown to promote success. As a result of this second review, I learned that research findings overwhelmingly suggest that students benefit from mathematics-specific learning strategy instruction (MLSI) when: (a) the students are enrolled in both a mathematics course and MLSI; (b) the MLSI course focuses on content and strategy use specific to the mathematics course; and (c) MLSI participation and attendance are mandatory.

*My unexpected catch* (Winne, 1995a) served as a reminder that "there are other fish in the sea." By restricting my searches to research related only to
developmental mathematics, I was, quite possibly, limiting my opportunities for learning. The expedition continues...

**Cast a Wide Net**

In this section, I review the literature on learning strategy instruction, beginning with an overview of research on mathematical problem solving and metacognition. Also included in this section are: research findings on students' use of learning strategies; an overview of a university study skills course (the traditional arena for learning strategy instruction); and a report on the relationship between course features and students' study activities.

**Problem Solving and Metacognition**

Research in mathematics education on problem solving has tended to focus on four areas of inquiry: identifying difficult problem features (early 1970s until early 1980s); describing characteristics of expert and novice problem solvers (late 1970s until mid 1980s); teaching problem-solving skills and heuristics (early 1980s to early 1990s); and understanding the role of metacognition in mathematical problem solving (early 1990s to present) (Lester, 1994). Early problem-solving research focused almost exclusively on task variables (Schoenfeld, 1992). This research, however, failed to consider the characteristics of the problem solver (i.e. traits, dispositions, background). Researchers eventually began to investigate the characteristics of good and bad problem solvers.

According to Lester (1994), research findings suggest that good problem solvers tend to focus their attention on structural features of a problem rather than surface features, are aware of their problem-solving strengths and weaknesses, and continually monitor their efforts during problem-solving activities (see Cai, 1994). Lester (1994), however, warned that, "trying to teach these ways to novices in a short amount of time may not result in desirable outcomes [because] problem-solving processes and heuristics develop slowly over time" (p. 665).
The research literature does provide some general information on problem-solving instruction (Schoenfeld, 1992; White & Kitchen, 1991). First, teaching students about problem-solving will be ineffective if students are not required to practice the strategies by solving many problems. Second, students will value problem-solving instruction only if problem solving is valued by the instructor. Finally, problem-solving skills develop slowly over a prolonged period of time.

Recently, research on the role of metacognition in mathematical problem solving has generated several interesting findings (Lester, 1994, pp. 666-667):

1. Effective metacognitive activity during problem solving requires knowing not only what and when to monitor, but also how to monitor.

2. Teaching students to be more aware of their cognitions and better monitors of their problem-solving actions should take place in the context of learning specific mathematics concepts and techniques.

3. The development of healthy metacognitive skills is difficult and often requires unlearning inappropriate metacognitive behaviors developed through experience.

There is evidence that "unlearning" is quite challenging for adult learners (Smith, 1997). The older strategies are typically favored by these students because they are more readily accessible, require less effort, and are closely connected to domain-specific (mis)conceptions (Pressley, 1995).

**Observing Strategy Use**

Stockley, Winne, Hadwin, & Nesbit (1997) investigated students' capabilities to diagnose learning difficulties in peers. A group of 106 educational psychology students (undergraduates) interviewed peers, examined their written coursework, and generated recommendations (written reports) for improving their "client's" studying strategies (Stockley et al., 1997, p. 1). Data consisted of
interview records and written reports. Using a qualitative methodology, data were analyzed thematically. The researchers found that students most often emphasized the obvious in their recommendations: time management, effective note-taking strategies, and elaboration tactics. Stockley et al. (1997) concluded that "students' diagnostic capabilities are marginal to weak" (p. 7).

**Teaching and Evaluating Strategy Use**

Each of the following summaries describes an investigation in which students were taught or instructed to use a specific learning/study strategy. These investigations focus on: comprehension monitoring, notetaking, concept mapping, self-questioning; and summarizing.

**Monitoring academic progress.** Swanson (1985) recognized that "many college students fail to monitor and change their study learning procedures even when faced with failing grades on tests and other homework assignments" (p. 28). In an attempt to help students learn to monitor and regulate their own learning, the researcher used journal writing assignments and metacognitive strategy checklists with a group of 24 college developmental readers. Students were given journal writing prompts related to required textbook reading assignments. They were asked, for example, to describe specific behaviors they used when reading the chapter. Most of the students were not accustomed to journal writing and had to be encouraged to write for a sustained period of time (more than 5 minutes) in order to avoid superficial responses.

Immediately after finishing the journal questions, students were required to complete a metacognitive strategy checklist. Students were instructed to check only those items on the checklist that described their behaviors while reading. Items included: "Read study guide questions before I started reading the chapter" and "When I didn't understand what I was reading I reread it" (Swanson, 1985, p. 36). Students took objective quizzes (covering the content of the reading assignment)
after completing the checklist. The researcher found that students who reported using the fewest strategies scored the lowest on objective quizzes. As the course progressed, the researcher also observed that students became more aware of the strategies that were effective as well as the strategies that were ineffective in the context of this particular course (see Zimmerman & Paulsen, 1995; MacGregor, 1993, for additional research on self-monitoring).

**Notetaking instruction.** O'Neill and Hynes (1985) investigated the relationship between notetaking ability and achievement with a group of college developmental reading students. Students were given a textbook selection to read and told to make notes on the material. After a designated period of time, the textbooks were surrendered, and the students were required to answer test questions using only their notes. Both literal and inferential questions were posed. According to the researchers, "the purpose of the test was not only to ascertain the manner in which students took notes but also to observe how well they were able to use this information to answer various types of questions" (O'Neill & Hynes, 1985, p. 83).

An analysis of 93 randomly-selected test papers and corresponding students' notes revealed that most students did recognize and use the major organizational patterns established by the author of the text. Students had difficulty, however, "sustaining a logical system of subordination between main ideas" (O'Neill & Hynes, 1985, p. 91). Many students had incomplete notes because they tended to write word for word instead of summarizing the information, and they simply failed to complete the notetaking portion of the assignment in the time allotted.

Students were most successful on the exam when the wording of the test question was the same as or similar to the wording of the text. Students were less successful when they were required to answer inferential questions. The researchers concluded that students have a minimal understanding of notetaking, are limited in their ability to utilize their own notes, and find it difficult to answer inferential
questions based on their notes (see Pollio, 1990, for a review of notetaking research).

**A meta-analysis.** Hadwin and Winne (1996) reviewed contemporary empirical studies that investigated students’ use of study strategies at the postsecondary level. The researchers considered only those studies that met the following criteria: a sample consisting of nondisabled, postsecondary students; a method involving the instruction and use of a study tactic or strategy; and data consisting of trace evidence of strategy use (as opposed to self-report only data). Additionally, the researchers reviewed only studies in which students applied strategies to novel tasks and were graded either directly or indirectly on their strategy use. Only 15 research articles were judged to meet the stated criteria.

The researchers found positive empirical support for the use of concept mapping and self-questioning in the context of regular university courses. Hadwin and Winne (1996) also found that monitoring the amount of time spent studying may be effective in authentic contexts.

**Learning from a lecture.** In a study conducted by King (1992), underprepared college students viewed a lecture, took notes, and engaged in a variety of study strategies in preparation for an immediate exam. Students from three sections of a remedial reading and study skills course were assigned to one of three conditions. One section of students was trained to generate and answer questions based on a lecture. Students in another section were trained in summarization techniques, and a third section of students was designated the control group. The control group students simply reviewed their lecture notes in preparation for the exam.

The researchers found that both self-questioning and summarizing were effective strategies for learning from a lecture. Summarizers scored highest on the immediate exam, with self-questioners running a close second. One week after the
lecture, a retention test was administered. The self-questioners outperformed the summarizers on this exam. Once again, the control group scored below both treatment groups.

**Study Skills Courses**

Many universities and colleges offer general study skills courses. According to Simpson, Hynd, Nist, and Burrell (1997), the purpose of these courses is to promote self-regulation and develop strategic learners. Supplemental Instruction and developmental studies labs (discussed previously in this review) are related to but distinct from general study skills courses (i.e. learning-to-learn courses).

**A summary.** In their article, Simpson et al. (1997) considered program goals, placement procedures, salient features, and evaluation methods for three different programs: Learning-to-Learn courses, Supplemental Instruction, and required programs. For the purpose of clarity, I have compiled a summary of the information found in this article (Figure 1). Because I have already investigated Supplemental Instruction and developmental studies labs elsewhere in this review, I will now focus on an overview of a Learning-to-Learn course.

**Learning-to-Learn course.** Claire Ellen Weinstein and her colleagues at the University of Texas have developed a Model of Strategic Learning (Weinstein, 1987, 1994, 1996a, 1996b). The Strategic Learning Model (Figure 2) emphasizes interactions among self-regulation, motivation (will), and learning strategies (skill). Central to the model is the individual learner. According to Weinstein (1994), strategic learners possess a variety of different types of knowledge including: "(a) knowledge about themselves as learners (e.g., learning strengths / weaknesses, preferences, goals); (b) knowledge about different types of academic tasks (e.g., reading for understanding, taking notes, listening to a lecture, taking tests); (c) knowledge about strategies and tactics for acquiring, integrating, and applying, and thinking about new learning; (d) prior content knowledge; and (e) knowledge of
both present and future contexts in which the knowledge could be useful" (p. 258). Expert learners are those individuals who, among other things, know how to use these five aspects of relevant knowledge to monitor their own progress and meet their individual learning goals.

Learner expertise, however, requires more than proficiency in the five different types of knowledge. "Strategic learners also have metacognitive awareness and control strategies they can use to orchestrate and manage their studying and learning" (Weinstein, 1994, p. 259). This involves the use of self-regulatory activities. Learning activities designed to enhance self-regulation dramatically impact all other components of the model. The activities included in the self-regulation component of the model are: time management, comprehension monitoring, stress management, and systematic approaches to learning and accomplishing academic tasks (e.g., setting goals, reflecting, monitoring, evaluating progress, and modifying actions).

The Model of Strategic Learning also includes a variety of components external to the learner. Expert learners are aware of these factors (e.g., teacher expectations, nature of the learning activity, social context, available resources) and use this information to increase achievement outcomes.

Students enrolled in this study strategies course engage in a variety of activities designed to address the various components of the model. The first part of the course is devoted to an introduction of the Model of Strategic Learning. Students then learn to generate management plans for common academic tasks (i.e. notetaking, learning from a lecture, preparing for and taking an exam); to set challenging, yet realistic academic goals; and to assess and revise their management plans and goals as needed. Each topic is related back to the Model of Strategic Learning in order to provide students with a schema for making sense of new information. During the second half of the course, additional topics are introduced.
These topics include (but are not limited to): knowledge-acquisition strategies, time management, reading strategies, attention and concentration, and dealing with procrastination. Finally, students learn how to adapt these strategies and skills to a variety of content courses.

Weinstein and her colleagues have found that participation in the Learning-to-Learn course is associated with improved grade point averages (both during and after course enrollment), higher retention rates for at-risk populations, and increased graduation rates.

Summary

The studies reviewed in this section were all related to the teaching of learning strategies. Some researchers investigated the use of isolated strategies, while others approached strategy instruction more holistically. In some cases instruction was embedded within a content course as an instructional/learning support mechanism. In other cases, learning strategy instruction was the primary focus of the course.
APPENDIX B:

Mathematics-Specific Learning Strategy Resources

The following pages contain learning-to-learn resources developed by the researcher for use with students enrolled in a college-level developmental mathematics course.
STUDENT DIRECTORY Information Sheet

Name: ________________________________

Local Address: _______________________

____________________________________

Local Phone: ________________

____________________________________

A class directory will be compiled by the instructor. Do you wish to have your phone number listed in this directory?

___ yes  ___ no

Student addresses will not be listed in the directory.

Copies of the directory will be made available to the entire class.

You may find this information useful as you begin to form study groups; as you encounter homework questions; and as you prepare for upcoming examinations.

The directory will also include the following information with each listing:

Please do not call before ____ a.m. or after ____ p.m.
Name: ____________________________ date: __________

Respond to each of the following statements by placing an "X" somewhere on the continuum from 0 to 10 (0 implies that you "strongly disagree" with the statement and 10 implies that you "strongly agree" with the statement).

I usually have a difficult time understanding mathematics.

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<td>Strongly Agree</td>
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I am confident in my ability to perform well on a mathematics test.

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<td>Strongly Agree</td>
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I know how to study mathematics.

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<tr>
<td>Strongly Disagree</td>
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<td>Strongly Agree</td>
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I am good at mathematics.

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<td>Strongly Agree</td>
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I usually ask questions when I do not understand.

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<td>Strongly Agree</td>
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I know where to go for help.

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<tbody>
<tr>
<td>Strongly Disagree</td>
<td>Strongly Agree</td>
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When a mathematics problem is difficult I can learn how to do it.

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<tr>
<td>Strongly Disagree</td>
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I am easily discouraged when working on a mathematics problem.

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Learning mathematics is important to me.

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<tr>
<td>Strongly Disagree</td>
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Getting good grades in mathematics is important to me.

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My success in mathematics depends heavily on the instructor.

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</table>
MATHEMATICS AUTOBIOGRAPHY

Purpose: This journal writing assignment will: a) allow students to assess their current mathematical situations in light of historical factors; and b) provide instructors with valuable student information such as student attributions of success and/or failure and students’ perceptions of their own academic control. This journal can also be revisited at the end of the course. Students may wish to add new chapters to their autobiographies and to reflect upon their in-course advancements.

Materials: Student Journal: Mathematical Autobiography (1 per student)

Time Required: 5 minutes to discuss the assignment in class; 30-60 minutes for students to complete the assignment at home

Getting Started: This student journal should be assigned early in the term (the first day of classes, if possible). Writing in a mathematics course will be new to many students. These students will need guidance and encouragement.

Before assigning this journal, the instructor must determine how the autobiographies will be read (ex: for content only; for grammatical correctness; for spelling). This information should be clearly conveyed to the students. The instructor must also determine whether or not the journals will be evaluated. The type of evaluation (ex: grade, pass/fail, etc) should also be made public.

Suggestions: Make copies of student journal entries for future reference;

Look for passages that address students’ current (both good and bad) mathematical learning strategies;

Recognize that some students may attribute their past successes to external factors (ex: good or nice teachers);

Discuss major themes that crosscut the journals with the entire class, perhaps as a way of saying, “You’re not alone.”
MATHEMATICS AUTOBIOGRAPHY

Describe (chronologically, if possible) your previous experiences with mathematics. You may wish to start with your first memory of mathematics and then discuss your elementary school, middle school, and high school mathematical experiences. What was the best problem you ever solved/explored using mathematics? Why did you select this problem as the BEST? Where are you now? (Attach additional sheets if necessary.)
LASSI Plus  Instructors Guide

**Purpose:**
The Learning and Study Strategies Inventory (LASSI) provides students with information about their current use of global learning strategies. This information can be used to target student deficiencies related to mathematical performance.

**Materials:**
The Learning and Study Strategies Inventory (1 per student); Mathematizing the LASSI transparency; Student Journal: LASSI Focus (1 per student); Student Journal: LASSI Reflection (1 per student)

**Time Required:**
10 minutes to discuss the administration and scoring of the LASSI (in class); 30 minutes for students to complete and score the LASSI (at home); 30 minutes to discuss the results (in class); 20 minutes for students to complete each journaling assignment (at home)

**Getting Started:**
Follow the guidelines for administering the LASSI.

On the day that students return to class with their scored instruments, be prepared to help students interpret their results and to lead a whole-class discussion that focuses on mathematics-specific learning strategies.

**Connections to Content:**
Use the **Mathematizing the LASSI** to evoke a whole-class discussion on percentiles.

**Suggestions:**
Collect mathematics-specific resources (ex: tips for testing, recommendations for reducing math anxiety) that address each of the ten LASSI categories;

Distribute resources based on Student Journal responses;

Encourage students to focus on improving only one or two areas at a time;

Distribute new Student Journals every two weeks.
1. What is a percentile?

2. What does it mean to score in the 80th percentile?

3. What does it mean to score in the 50th percentile?

4. How are percentiles determined?

5. Why does ATT range from 19 to 39 while SMI ranges from 8 to 25?

6. Where else are percentiles used?
RECALL THE FOLLOWING JOURNAL PROMPT:

Evaluate your present level of mastery in this area by placing an "X" somewhere on the following number line.

A __________________________________________ B

A = your beginning level of mastery in this area (two weeks ago)
B = your desired level of mastery in this area
X = your current level of mastery in this area

1. Review your response to this journal prompt. How could you determine the approximate percentage your skills have increased?

2. How could you improve upon the accuracy of your approximation?

3. Explain the following statement: In two weeks "X" becomes "A."
STUDENT JOURNAL

Name:_________________________ Date:____

Select one of the 10 scales from the LASSI to focus on for the next two weeks.

Which area did you select?  

Why did you select this area?

What will you do to improve your skills in this area?
STUDENT JOURNAL

Name:_____________________________   Date:______

You have been focusing on improving your skills in the area of ________ (LASSII) during the last two weeks.

What did you do to improve your skills in this area?

Evaluate your present level of mastery in this area by placing an "X" somewhere on the following number line.

|________________________________________|

A                B

A = your beginning level of mastery in this area (two weeks ago)
B = your desired level of mastery in this area
X = your current level of mastery in this area

Where do you go from here?
<table>
<thead>
<tr>
<th><strong>INVESTIGATING TEXTBOOK FEATURES</strong></th>
<th><strong>Instructors Guide</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Purpose:</strong></td>
<td>Many students are unaware of the features of their mathematics textbooks. This activity introduces some of the most important features.</td>
</tr>
<tr>
<td><strong>Materials:</strong></td>
<td>Overhead transparencies of selected pages from the student text</td>
</tr>
<tr>
<td><strong>Possible Textbook Features:</strong></td>
<td>A letter to the student about the features of the text (often found in the preface);</td>
</tr>
<tr>
<td></td>
<td><strong>Bold</strong> script to signify important words/ideas;</td>
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<tr>
<td></td>
<td>Color coding;</td>
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<tr>
<td></td>
<td>Examples;</td>
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<tr>
<td></td>
<td>Section outlines (often found below section headings);</td>
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<tr>
<td></td>
<td>Boxes used to offset information (summaries, formulas, etc.);</td>
</tr>
<tr>
<td></td>
<td>Chapter summaries/reviews;</td>
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<tr>
<td></td>
<td>Solutions to select problems (often found in the back of the book);</td>
</tr>
<tr>
<td></td>
<td>Table of Contents; Glossary; Index</td>
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<tr>
<td><strong>Ideas:</strong></td>
<td>Ask students to identify as many textbook features as possible (using the overhead);</td>
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<tr>
<td></td>
<td>Create a homework assignment that explores textbook features;</td>
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<td>Use the transparencies to model reading a text (Noting that mathematics texts are not necessarily read left-to-right, top-to-bottom);</td>
</tr>
<tr>
<td></td>
<td>Explain how an instructor uses the text to develop his/her lectures/lessons.</td>
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</table>
LEARNING TO ASK GOOD QUESTIONS

The Problem: Developmental mathematics students often have difficulty structuring good questions. For example, at the end of a lesson, an instructor may ask, "Are there any questions?". It is not uncommon for a student to respond, "I don't understand any of this." One of the most basic problems with this response is that it is a statement, not a question. Statements of this nature are difficult to address.

The Goal: Instructors can help students help themselves by teaching (and requiring) students to structure good questions.

Suggestions: Help students recognize that their statements are not questions.

Student: I don't get it.

Instructor: Can you rephrase your response? Structure a specific question that will help me clarify the information for you. Which part of the lesson do you find difficult? What do you understand? Structure a specific question that focuses on the part of lesson that is unclear.

Student: You are confusing everyone...

Instructor: Think about how this information could be clarified for you...Now, ask me a question.

Model good questioning strategies.

Instructor: A good question, at this point, would be...

Clarify and restate student questions.

Instructor: Let me see if I understand your question, are you asking...

Refrain from responding to statements (insist on questions).
**Purpose:** The purpose of this activity is to help students develop strategies for recording mathematical information.

**Materials:** Sample note-taking skeletons (on both ruled paper and grid paper); Student Journal; Taking Notes (1 per student); Today’s Lecture transparency

**Time Required:** 10 minutes in class to discuss mathematical note taking; 30 minutes at home for journaling

**Getting Started:** Using overhead transparencies, present the sample note-taking skeletons.

The lecture topic and the section number (from the textbook) should be written at the top of the page. Students should leave a space for a summary of the main idea(s) of the lesson. Summaries should be completed at the close of the lecture.

The left-hand margin should be reserved for indexing (ex: definitions, examples, formulas). The right-hand margin should be used for recording questions. These questions may arise during the lecture or as the student reviews his/her notes.

The Today’s Lecture transparency can be used at the close of each class period to review the material presented and to help students improve their note-taking skills.

**Suggestions:** Model these note-taking strategies during the lecture presentation (on the chalkboard or overhead);

Use key words and phrases in the presentation, such as “definition,” “example,” and “main idea;”

Implementing a note-taking strategy may be difficult for some student—encourage them to stick with it;

Remind the students that in addition to taking good notes, they should read, revise, and review their writings;

Require students to maintain a notebook—good notes need good homes.
TODAY'S LECTURE

The TOPIC of today's lecture was...

The MAIN IDEAS discussed within this topic were...

The terms DEFINED were...

The QUESTIONS that were raised during lecture included...

We might EXPECT tomorrow's topic to be...
LEARNING ABOUT MATHEMATICS TESTS

Instructors Guide

Purpose: These materials will help students understand the nature of a mathematics test and will provide opportunities for students to learn more about themselves and about the subject matter.

Materials: Review Sheet (1 per student); Student Homework (1 per student); Student Journal (1 per student)

Review: The content of most developmental mathematics courses can be described categorically using 3-6 headings. In some cases, these categories may be: Integers, Solving, Lines, Fractions/Decimals/Percents; or Lines, Quadratic Equations, Roots & Powers, Rational Expressions. The main ideas of the course are described within these categories.

Using the Sample Midterm Review as a model, construct a categorical review. Before the first exam, provide and discuss a completed review chart with the entire class. In preparation for the second exam, provide the review chart without sub-category entries. Begin completing the chart, as a group, in class, and assign the remainder as homework. By the third exam, students should be ready to complete the chart on their own.

Homework: This assignment requires students to both correct their exams and analyze their mistakes. Low-scoring individuals may, otherwise, be reluctant to look beyond their grades. Students will identify gaps in their mathematical knowledge, and will begin to recognize that multiple missed problems do not necessarily imply multiple mathematical gaps/errors (Student: "I missed all of these problems because of a sign error.").

NOTE: Encourage students to explore available resources.

Journal: This journal highlights the relationship between the actions of the student and the student's mathematics test score. Students are required to reflect on their previous actions and to devise new plans, as needed.

NOTE: Be prepared to address mathematical misconceptions (ex: one absence = 99% attendance).
STUDENT HOMEWORK

Name: ____________________________ Date: ___ __

For each problem on Exam # ___ that you missed (or lost any points on):

a. Write the problem number.
b. Write a brief statement about what went wrong (if applicable).
c. Correct the problem. Use words to explain the processes you use.

For each problem on Exam # ___ that you omitted:

a. Write the problem number.
b. Complete the problem. Show as much work as possible.

For each correct problem on Exam # ___:

a. Check the problem for extending or clarifying questions.
b. Write the problem number and answer the question(s).

Please use blank paper to complete this assignment (i.e. do not write the corrections on the actual exam).

Turn in your exam with this assignment.
STUDENT JOURNAL

Name: ____________________________ Date: ______

Give your best rough estimate for each of the following:

1. I attend math class ___ percent of the time.

2. I turn in my homework assignments on the day they are due ___ percent of the time.

3. I eventually turn in ___ percent of my homework assignments.

4. If I don't get everything correct on my homework, I revise my work ___ percent of the time.

5. I would classify ___ percent of the homework as very difficult.

6. When I am having trouble with a problem I ask for help ___ percent of the time.

Look at your score on Exam #____. Is there a relationship between your exam score and any of the percentages above? Are you "on the right track"? Do you need a new plan of action? Comment.
Developmental mathematics students often overestimate the amount of time they spend studying mathematics. A student may worry about an upcoming exam for an entire day, study for only 30 minutes, and feel as though he/she has spent an entire day focused on mathematics. Additionally, the 30-minute study session may have seemed like two hours.

These resources are intended to help students: a) record the amount of time actually spent studying mathematics; b) set realistic course and study session goals; and c) monitor mathematical progress.

Study Session Goal Sheet (2 per student per week); Student Journal (1 per student); Constructing Useful Goals transparency; Words into Actions transparency; Useful Goals? transparency

Distribute and discuss the Study Session Goal Sheet. This chart is used to record students' efforts outside the classroom. For each study session, students should write detailed, short-term goals. Examples may be helpful. A study session goal could be: organize my mathematics notebook; read and clarify my notes from today's lecture; complete the homework assignment on graphing parabolas; review Chapter 5; or get help from the tutoring center on factoring.

Students should also develop proximal course goals (Student Journal). These goals may be more difficult for students to structure. For this reason, the Structuring Useful Goals and Words into Actions transparencies are provided. Additionally, the Useful Goals? transparency can be used during whole-class discussion.

By rating study sessions (1-10), students can monitor and improve their productivity. Periodically reflecting on proximal course goals will help students recognize their progress.
**STUDY TIPS**

**Idea:** Recommend that students form study groups early. Students may need instruction on forming study groups.

Study group members should determine: a) where to meet; b) when to meet; c) how often to meet; and d) what to discuss. Group size should range from 2-5 individuals.

Groups should periodically assess their effectiveness.

**Idea:** Students should be encouraged to use available resources during study sessions.

**Idea:** Encourage students to schedule study sessions during hours that resources are available.

**Idea:** Students may need help determining when to persist and when to ask for help. Encourage students to persist while attempting to solve a problem, but not to the point of frustration.

**Idea:** Recommend that students warm-up before beginning a homework assignment. The warm-up may consist of rereading class notes or working examples from the text.

**Idea:** Provide strategies for problem solving.
<table>
<thead>
<tr>
<th>Date</th>
<th>Amount of Time Scheduled for Session</th>
<th>GOALS FOR THE SESSION</th>
<th>Start Time</th>
<th>Session Rating (1-10)</th>
<th>Stop Time</th>
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</table>
STUDENT JOURNAL

Name: ______________________________ Date: ______

State your goals (with respect to this class) for the next two weeks.

What will you do to attain these goals? Be specific.

* * * * * * * * * * *

(Complete this portion at the end of the two-week period.)
Did you reach this goal? What did you do? What will you continue to do?
USEFUL GOALS?

Which of the following goals are useful goals? How could each be improved upon?

* I want to ace this class.

* For the next two weeks I want to spend 30 minutes each afternoon (between 1:00 and 4:00) reviewing Math.

* For the entire quarter I want to attend every class and turn in every assignment on time.

* I want to study hard for the exam and get a great grade as a result.

* I want to learn more about graphing before the first exam—specifically: slopes and intercepts.

* I want to learn how to use my calculator more effectively.
CONSTRUCTING USEFUL GOALS

1. State your goal. (Be specific.)

2. How will you know that your goal has been met? What evidence will you use to support this?

   (If you are unable to specifically answer these questions, then go back to #1 and revise your goal.)

3. Is this goal attainable? Is it realistic?

   (If not, then go back to #1 and revise your goal.)

4. When will you start working toward this goal?

5. When will you stop to evaluate your progress?
WORDS INTO ACTIONS

1. What will **you** DO to attain your goal(s)? Be specific.

2. When will you do this? On what days? At what times? How often?

3. Where will you do this?

4. With whom will you do this?

5. What additional information do you need? Instructor office hours? Directions to the tutoring center?

6. How will you monitor and record your progress?
**Purpose:** These activities and ideas are intended to: a) introduce students to a variety of mathematics resources; and b) encourage students to use the available resources.

**Materials:** Student Directory (1 per student); Student Journal (1 per student)

**Ideas:** Create a student directory and encourage students to use the directory to form study groups and to call one another with homework questions;

Attach a campus map to the syllabus to help students locate campus resources (tutoring labs, bookstores, etc.);

Ask students to compile their own lists of mathematics resources before providing departmental lists;

Arrange for a class meeting to be held at the tutoring center (1 day only);

Invite resource directors/assistants to speak to the class about available resources (5 minutes at beginning of class);

Highlight a different resource each week;

Ask students to share their experiences with campus resources;

Encourage students to register for subsequent mathematics courses with members of their own study groups.

**Note:** Some students may not want their phone numbers listed in the class directory. Their names, however, should appear in the directory. In place of their phone numbers, write “unlisted.” Every student should receive a copy of this resource.
STUDENT JOURNAL

Name: ___________________________ Date: _____

There are many resources available to assist students enrolled in mathematics courses. Some (but not all) of these resources have been discussed in class. You are charged with creating a comprehensive mathematics resource directory. Please include all pertinent information with each resource (i.e. cost, hours of operation, etc.).

In addition, you will select one assistance option to investigate further. In other words, you will experience a resource.

The information collected will be compiled by the instructor and distributed to the entire class.

GUIDELINES

* The resource must be available to EVERYONE.

* ALL pertinent information must be included in your report.

* Students may work in TEAMS to complete this project. Each student, however, must experience a different resource option.

SAMPLE PROBLEMS

Before you can ask for help you need a reason for assistance. Consider the following problems:

Solve for P: \( A = P + Prt \)  
Solve for x: \( \frac{x + 3}{x + 1} = 5 \)
GOALS FOR WINTER 1998

My attendance goals for Math____ are:

My learning/performance goals for Math____ are:

In order to achieve these goals I will (plan of action):

If I need help reaching my goals, I will:
APPENDIX C:

Interview Protocols
INTERVIEW PROTOCOL
(Initial)

Name: ______________ Date: ____________ Time: __________________

Enrollment Status: full time/ part time  Age: _______ Housing: on/off campus

Major: _________ Mathematics Required for Degree: ______________________

Other Responsibilities: family/job _________________________________

How did you approach studying (last quarter) in Math 050?

Explain how _____________ (strategy) was a useful for you. (repeat for each strategy named above.)

How much time did you devote to ___________ (each strategy)?

How did your approaches to studying in Math 050 change as the quarter progressed? Why?

What goal(s) were you working toward? Did you reach your goal(s)?
Interview Protocol (Initial)
page 2

What advice would you give to a friend who has just enrolled in Math 050?

How will you approach studying (this quarter) in Math 104?

What is your plan of action?

What are your goals (short term/long term) with respect to Math 104?

What are your grade expectations in Math 104?

Complete the following sentence:
  I know I can learn the material in Math 104 if...
INTERVIEW PROTOCOL
(After Exam #1)

Name: ___________________  Date: _______  Time: ________________

How many Math 104 lectures did you attend?  miss?  (Explain absences)

How many Math 104 recitation sessions did you attend?  miss?  (Explain absences)

What grade do you expect to receive on Exam #1?

What topics were covered on the exam?

What do you think you missed?  Why?

How did you prepare for the exam?

What percentage of the homework assignments did you complete?  Did you verify that your solutions were correct?  How?

What percentage of the homework assignments did you find to be difficult/challenging?  How did you overcome these difficulties/challenges?
Interview Protocol (After Exam #1)
page 2

How useful were your lecture notes? (look at samples of student's notes)

How often did you go to your instructor's office for help (where is your instructor's office/ what are his/her office hours)? attend a tutoring session? study with a partner/group? ask questions during the recitation? read your textbook?

What do you wish you would have done differently in preparing for the first exam?

How will you prepare for the next exam? (plan of action)

How do you believe you will benefit from this plan?
APPENDIX D:

Additional Data on Original Investigation Participants

The following pages contain information on the seventeen students who completed the strategy-embedded developmental mathematics course and continued studying mathematics.
Additional Data

Seventeen of the 19 original investigation participants continued to study mathematics after completing the strategy-embedded developmental mathematics course. Twelve students (including the eight primary participants in the second phase of this investigation) enrolled in a college algebra course during the following term. The experiences of Tad, Johnny, Jake, Donovan, Kelly, Mary, Rachel, and Estelle were discussed in detail in the previous chapter. The other four students who attempted college algebra during the winter quarter were Mark, Vernon, Candie, and Lisa.

Mark barely passed the developmental mathematics course with a D and struggled throughout his enrollment in college algebra. After failing college algebra twice (winter and spring quarters), Mark decided to take the course at a community college where the class size would be smaller. He felt that this factor would help him succeed.

Vernon continued to hold two jobs throughout the winter term and as a result (his assertion) failed the college algebra course. He quit his night job before the spring quarter began and was able to eventually pass college algebra. Candie spent much of the winter and spring terms caring for a sick family member. She passed college algebra on her second attempt. Lisa passed college algebra on her first attempt and continued enrolling in mathematics courses. She reported using many of the learning strategies that had been introduced during the
strategy-embedded developmental mathematics course (for example: reading, notetaking, using resources, test preparation strategies).

Amy, Jarod, and Katie enrolled in a second developmental mathematics course (Developmental Mathematics 2) after completing the strategy-embedded course. Jarod confessed that it was "hard to go to class when it was cold outside." He was not surprised when he failed the course. Attendance was also a problem for Shawn. Shawn (who failed the strategy-embedded developmental mathematics course) not only repeated developmental mathematics during the winter term, but also duplicated his course-related behaviors.

The mathematics courses taken during the 1997-1998 academic year by the 17 original investigation participants are summarized in Figure 48. Course grades are also included in this chart.

These students took responsibility for their own successes and failures. If they failed, they understood why they had failed, and they attributed their failures to changeable behaviors rather than notions of fixed ability.
<table>
<thead>
<tr>
<th>Name</th>
<th>Autumn 1997 Developmental Mathematics 1 Course Grade</th>
<th>Winter 1998 Mathematics Course &amp; Course Grade</th>
<th>Spring 1998 Mathematics Course &amp; Course Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tad</td>
<td>A</td>
<td>D</td>
<td>withdrew</td>
</tr>
<tr>
<td>Johnny</td>
<td>B</td>
<td>C</td>
<td>Survey of Math</td>
</tr>
<tr>
<td>Jake</td>
<td>B-</td>
<td>E</td>
<td>Developmental Mathematics 2</td>
</tr>
<tr>
<td>Mary</td>
<td>B-</td>
<td>withdrew</td>
<td>C+</td>
</tr>
<tr>
<td>Donovan</td>
<td>C</td>
<td></td>
<td>no math course</td>
</tr>
<tr>
<td>Rachel</td>
<td>A</td>
<td>B</td>
<td>B+</td>
</tr>
<tr>
<td>Estelle</td>
<td>B+</td>
<td>C</td>
<td>A-</td>
</tr>
<tr>
<td>Kelly</td>
<td>B-</td>
<td>D</td>
<td>C-</td>
</tr>
<tr>
<td>Mark</td>
<td>D</td>
<td>E</td>
<td></td>
</tr>
<tr>
<td>Vernon</td>
<td>C-</td>
<td>E</td>
<td>C+</td>
</tr>
<tr>
<td>Candie</td>
<td>B</td>
<td>E</td>
<td>D+</td>
</tr>
<tr>
<td>Lisa</td>
<td>A</td>
<td>A-</td>
<td></td>
</tr>
<tr>
<td>Amy</td>
<td>A</td>
<td>C-</td>
<td></td>
</tr>
<tr>
<td>Jarod</td>
<td>C</td>
<td>E</td>
<td></td>
</tr>
<tr>
<td>Katie</td>
<td>B-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shawn</td>
<td>E</td>
<td>E</td>
<td></td>
</tr>
<tr>
<td>Lenora</td>
<td>E</td>
<td>B+</td>
<td></td>
</tr>
<tr>
<td>Kristin</td>
<td>C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Janice</td>
<td>C</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 48: Follow-up data on original investigation participants