The Use of Self-Regulated Learning, Formative Assessment, and Mastery Learning to Assist Students Enrolled in Developmental Mathematics: A Demonstration Project

John Hudesman
New York City College of Technology & Center for Advanced Study in Education, CUNY Graduate School and University Center

Nicholas Millet
New York City College of Technology

Grazyna Niezgoda
New York City College of Technology

Sandie Han
New York City College of Technology

Bert Flugman
Center for Advanced Study in Education, CUNY Graduate School and University Center

Abstract

This paper outlines a program that combines traditional content formative assessment together with self-regulated learning (SRL) and mastery learning features, to assist at-risk students from two-year and four-year colleges that were enrolled in a developmental mathematics course. The program results support a relationship between the students' level of engagement in the program and their academic success. We also found that both successful and unsuccessful students had very positive perceptions of the program, in contrast to their previous experiences in mathematics classes.

Keywords. Formative assessment, self-regulated learning, developmental mathematics, student engagement

Introduction

The mathematics readiness of students entering college is a major concern. In a recent study from the American Diploma Project (2010) it was reported that 81% of twelfth graders were rated as having below a basic level of performance in Algebra I, and 98% of twelfth graders needed additional preparation in Algebra II. As a result there is an overflow of demand for developmental mathematics courses at the college level. For example, Lutzer, Rodi, Kirkman, and Maxwell (2007) found that in some community college mathematics departments, developmental coursework comprised half of all of the department offerings. However, once enrolled in a developmental mathematics course, the picture becomes still bleaker. Bailey (2009) reported that as a consequence of the students' lack of preparation they can require up to two years of developmental mathematics course work. As a

 ISSN 2094-1420

result, most of these students are unable to endure the challenge and leave school. These findings parallel those reported by the Carnegie Foundation (2009) in that between 60% and 70% of developmental mathematics students do not successfully complete the prescribed sequence of required courses.

This paper described how a self-regulated learning (SRL), formative assessment, and mastery learning program can provide an effective and supportive environment for students, many of whom have failed developmental mathematics courses multiple times. We will describe how the program was implemented, how it emphasized the constructive use of feedback, and how students' reacted to and were affected by it.

Formative Assessment. Formative assessment programs can be of significant assistance in helping students to improve their academic performance. Black and Wiliam (1998a, 1998b, 2009) have dramatically highlighted formative assessment's contribution to pre-college student learning. They concluded that achievement gains generated by using formative assessment across a range of content domains were among the largest ever reported for an education intervention, with the largest gains realized among low achievers. Similarly, Hattie and Timperely (2007) reviewed 196 K – 12 formative assessment and feedback studies and found a positive mean effect size of 0.79 for achievement measures - an effect greater than students' socioeconomic background, and reduced class size.

However, it should be noted that not all formative assessment programs are equally successful. For example, Heritage (2010) emphasized the need to include formative assessments as part of the ongoing instructional process as opposed to just relying on the information provided to students by a quiz or other instrument. Similarly, Sadler (1989) describes successful formative assessment programs as starting with an assessment instrument but then requiring instructors to use the assessment to change their instruction. It is also necessary that students demonstrate that they can use the feedback generated by the assessment to make changes in how they approach their learning. Furthermore, Hattie and Timperely (2007) cautioned that the effect sizes for formative assessment programs varied widely depending upon the type of feedback that instructors provided for their students. For example, positive or negative reinforcement feedback alone was far less effective than feedback that included specific guidance on how to improve performance.

Self-Regulated Learning (SRL). To date, almost all of formative assessment interventions have emphasized content competency to the exclusion of "learning how to learn" or metacognitive, and self-regulatory skill development. We believe that formative assessment related to course content can be significantly improved upon when students' self-regulatory and metacognitive competencies are also explicitly targeted for development during the assessment process.

The SRL approach guiding our work is based on models of self-regulated learning developed by Zimmerman (2000, 2002, and 2006) and Grant (2003, 2008).

 ISSN 2094-1420

Our approach uses a psycho-educational model characterized by continuous feedback cycles where each feedback cycle is broken down into three main phases, as illustrated in Figure 1. The first is a *planning phase*, in which students review their past efforts, conduct academic task analyses, select those strategies that best address their specific learning challenge, set identifiable goals, and make self-efficacy and self-evaluation judgments to assess the accuracy of their level of understanding and content mastery. Next is a *practice phase*, in which students implement their plans, monitor their progress, and make real-time adjustments to their learning plans. This is followed by an *evaluation phase*, in which students assess each strategy's effectiveness in progressing towards the goal. Students then build on the successful strategies and/or modify or replace less effective ones. The students' responses from the evaluation phase become the basis for the planning phase of the next SRL cycle.

The power of SRL competence is highlighted in a classic study in social learning theory by Zimmerman and Bandura (1994). They demonstrated that students' SRL skill levels were more highly correlated with their college grade point average than were their scores on standardized tests such as the SAT. More recently, Zimmerman, Moylan, Hudesman, White, and Flugman, (2011), Hudesman, Zimmerman, and Flugman (2010), and Blank, Hudesman, and Zimmerman (2008) demonstrated that an SRL program with formative assessment and mastery learning features can improve the performance of students in developmental mathematics and other STEM disciplines.

Feedback: A Key Element in Both Models. Implicit in an SRL program with formative assessment and mastery learning features is that feedback is a key element in these approaches. For example, in formative assessment, both students and teachers are expected to use the feedback from classroom assessments to change their behaviors; teachers by changing their instruction and students by acting constructively on the feedback to change how they learn. Similarly, SRL derives much of its 'power' as a function of its iterative process; each time students complete an SRL cycle, they acquire more feedback and therefore, come closer to achieving their learning goals. Students begin to understand that learning is directly related to experimenting with different strategies, a notable shift from the common student perception that academic success is simply a function of innate ability or some other external factor (Zimmerman 2002).

The Research Questions

1. Is student engagement (as indicated by their use of a self-reflection and revision form and their attendance) related to the successful completion of a developmental mathematics course?
2. Do students develop positive perceptions of a developmental mathematics course that includes a variety of SRL, formative assessment, and mastery learning supports?

 ISSN 2094-1420

The SRL Program Method

The Setting

This demonstration program was implemented at a large urban university with multiple community (two-year), comprehensive (two year and four year), and senior level (four year) college campuses. As part of the university admissions procedure all undergraduate students are required to take placement tests in reading comprehension, writing, and mathematics. The mathematics section of the placement examination consists of the pre-algebra and algebra sections of the Computer-Adaptive Placement Assessment and Support System (COMPASS), i. e., the mathematics portion of the ACT (1997, 2006). Any student who failed either portion of the COMPASS was required to take a noncredit developmental mathematics course. After passing this course, the student was again eligible to retake the COMPASS. Students who passed this examination were then eligible to take a variety of credit bearing courses. Students who again failed the COMPASS were generally expected to retake the developmental mathematics course before they could retake the test. As a consequence, these students would also not be eligible to register for a variety of other college-level courses.

Program Participants

Each undergraduate college hosts a university funded program that provides additional educational support, counseling, and financial aid to at-risk students. Twenty-eight special program students from eight different campuses participated in this study, including students from three community colleges, two comprehensive colleges, and three senior colleges. Eleven percent of the participants were male and 89 percent were female. University wide women represent 61.3% of the special program enrollees. All of the students were either black or Hispanic. University wide, Black and Hispanic students represent about 65 % of the special program enrollees (Office of Institutional Research, 2012). All the program participants had previously failed the COMPASS test, most of them multiple times. These participants were not typical incoming developmental mathematics students in that they had already attempted a mean of 32 credits and had a mean GPA of 2.11. Implicit in these statistics is that this student group was not eligible to take a variety of STEM related course, many of which are required for graduation.

During the orientation and initial phase of the program, almost all of the students indicated that they were 'not good at mathematics,' and referred to their COMPASS results as well as their performance in prior mathematics classes in high school and college. Therefore, a major focus of this demonstration program was to structure a supportive environment based on the constructive use of feedback, as reflected in SRL, formative assessment, and mastery learning, e. g., that students

 ISSN 2094-1420

learn that quiz errors are not measures of failure but rather they should be viewed as starting points for additional learning.

The Class

There were two sections of SRL developmental mathematics, each with 14 students. This low number of students per section is typical for special program summer session developmental mathematics courses. Each mathematics section met four days a week for five weeks for a total of 20 sessions. Each session lasted three hours. At the end of the course, students were again eligible to retake the COMPASS

Instructors

Two instructors, GN and SH, who are also co-authors of this paper, each taught one section of the course. Both instructors had previously taught SRL developmental mathematics classes. Prior to the start of class there was one day of training for the instructors during which program features were reviewed along with the particular needs of this student group. Throughout the program instructors were observed on a regular basis. Post observation discussions with instructors were focused on optimizing the implementation of the program interventions. Discussions with instructors were also used to obtain suggestions on how to improve the program.

Counseling

The program included the services of a special program counselor (NM), who is also a coauthor. His role was to explain and reinforce the instructor's use of metacognitive and SRL features throughout the course. For example, during class he engaged students in a variety of exercises designed to demonstrate the relationship between SRL behaviors and academic outcomes. Some examples of the exercises are described in a later section of this paper. He also worked with students individually to support their use of good academic behaviors and SRL strategies.

Tutoring

Traditionally tutors are considered to be part of the instructional team at all special program summer mathematics courses. The role of the tutor is generally defined by the instructor. In our program, the tutor was responsible for scoring and returning the quizzes within the same class period, working with students on their reflection and revision forms, and being available for general assistance.

 ISSN 2094-1420

The Five Step Enhanced Formative Assessment Program Using SRL

This section summarizes the five step SRL, formative assessment, and mastery learning program and then describes each portion in more detail. Similar program descriptions can also be found in the work of Zimmerman, Moylan, Hudesman, White, and Flugman (2011), and Hudesman, Crosby, Flugman, Everson, Isaac, and Clay (2012). The five steps of the EFAP-SRL program are summarized as follows:

1) Instructors administer specially constructed quizzes that are designed to assess both the students' mathematics and SRL competencies;

2) Instructors (or tutors) review and grade the quizzes in order to provide students with feedback about both their content and SRL competencies; instructors also use quiz feedback to adjust their instruction;

3) Students complete a specially constructed Self-Reflection and Mastery Learning Form for each incorrectly answered quiz problem. This procedure affords them an opportunity to reflect on, and then improve, both the mathematics content and SRL processes that were incorrectly applied;

4) Instructors review the completed Self-Reflection and Mastery Learning Forms to determine the degree to which students have mastered the appropriate mathematics and SRL skills. Based on the instructor's evaluation of their work, students can earn up to the total value of the original quiz question. Based on the data, instructors also have an additional opportunity to make changes to the mathematics content and SRL topics to be covered in upcoming lessons;

5) Instructors use the feedback provided by the quiz and self-reflection/mastery learning form as the basis for ongoing class discussions and exercises, during which students discuss the relationship between their mathematics content and SRL skills. These discussions are the starting point for students to redesign a plan to improve both skill areas.

The implementation of each step is described below.

1. Mathematics Quizzes. At least once a week students took a short specially formatted quiz. The procedure for each quiz was as follows. When completing the top portion of the quiz, students were asked to predict their quiz grade and to enter the amount of time they spent preparing for the quiz. Once they started the quiz, the students were asked to read each question, but before answering it, they were asked to make a self-efficacy judgment indicating how confident they were that they could correctly solve the problem. After attempting to solve the problem, students were asked to make a second self-evaluation judgment, indicating how confident

 ISSN 2094-1420

they were that they had correctly solved the problem. A sample quiz formatted with the self-efficacy and self-evaluation judgments is illustrated in Appendix A.

2. Scoring the quizzes and providing feedback. By reviewing both the students' mathematics content together with their SRL judgments, instructors assembled information that they could use to provide feedback for students. As a consequence, and, after determining those areas that students struggled with the most, instructors could modify their instruction. The quiz also provided the instructors with information about the relationship between the students' quiz scores (i.e., content competencies) and the self-efficacy and self-evaluation judgments (i.e., SRL competencies). Having access to *both* the students' academic content and metacognitive information is important because struggling students frequently make more optimistic predictions about their knowledge than are warranted by their actual quiz scores, indicating that they often do not recognize the difference between "what they actually know" and "what they think they know" (Tobias & Everson, 2002). As a result of this false belief, these students often do not feel any need to remedy the situation by changing their "learning how to learn" behaviors. As a result, they continue a destructive cycle of poor planning and poor academic outcomes. Being able to provide students with ongoing feedback about the relationship between their actual performance, i.e., quiz score, and their SRL competencies, e.g., predicted scores, and the relationship between their preparation time and their self-efficacy and self-evaluations judgments is critical to improving the students' mathematics and metacognitive skill sets.

3. The SRL Mathematics Self-Reflection and Mastery Learning Form. For each incorrectly answered quiz question, students were expected to complete a separate Self-Reflection and Mastery Learning Form. This form was designed to further assist students in assessing the relationship between their content knowledge and their ability to use critical SRL tools. In the first section of this form, students were asked to: 1) compare their predicted quiz score and their actual quiz score and explain any significant discrepancy; 2) evaluate the accuracy of their academic confidence judgments, i.e., their self-efficacy and self-evaluation judgments, and compare them to their actual quiz score; 3) based on the instructor's written feedback and/or prior class discussions, indicate which strategies were incorrectly applied when they attempted to solve the problem.

In the second section of the EFAP-SRL Reflection and Mastery Learning Form, students were again required to solve the original problem, but this time they also needed to include a written description of the specific mathematics strategies and procedures involved in their work. Students were also required to use these same mathematics strategies to solve a similar problem. A sample self-reflection form is illustrated in Appendix B.

4. Scoring the Self-Reflection and Mastery Learning Form. The SRL Reflection and Mastery Learning Form is based on a mastery learning approach in which students are given multiple opportunities to use feedback in order to improve their performance. By completing the form, students had an opportunity to demonstrate the degree to which they could constructively use feedback to master both the mathematics and metacognitive competencies necessary to solve the problem. Students who demonstrated a complete mastery on this self-reflection and mastery form could earn up to 100% of the original credit for a problem. Instructors again used the information from the Reflection and Mastery Learning Form to plan lessons that demonstrated the relationship between mathematics content and metacognitive competencies.

5. Classroom Discussions and Exercises. Instructors are expected to have ongoing class discussions that focus on the relationship between how students effectively learn mathematics content while enhancing their self-regulation skills. One such example involves having students create individual graphs that illustrate the relationship between their SRL judgments (self-efficacy and self-evaluation judgments) and their quiz scores. In another exercise, instructors might ask students to graph their quiz predictions together with how much time they spent preparing for the quiz against their actual quiz grades. The students' responses are then listed on the board and graphed. The results often demonstrate an obvious correlation between the students' preparation time and their quiz scores. Students are then asked to use the feedback from this exercise to design a revised plan for improving their work.

Results

Of the 28 students who started the program, one student dropped out for medical reasons at the start of the program, one student left after she was accepted at another university, and three other students had already passed the COMPASS at the start of the course, but two of them elected to stay and use the course as an opportunity for further review. Eleven of the remaining 23 (48%) students passed the course and the COMPASS examination. According to the Carnegie report (2009) only 30% to 40% of the students enrolled in developmental mathematics courses can be expected to pass. Similarly, the range of pass rates on the COMPASS at one (participating) college was from 25% - 49%, a statistic similar to that report by the Carnegie Foundation. However, the project participants cannot be considered to be typical enrollees since most of them had already failed the course multiple times and would reasonably be expected to have lower pass rates. However, it was not possible to verify this information since no university-wide statistics were available for special program students who failed the course on multiple occasions.

 ISSN 2094-1420

Table 1

Descriptive Statistics, Percentages, and Chi-Square tests for Academic Progress Measures by Groups in Developmental Mathematics

Academic Progress Measures	Groups: Passed the Course (11) n	M	(%)	Failed the Course (12) n	M	(%)	t	p
Pre-COMPASS – Pre-Algebra [1]	10	26.90		7	26.86		0.01	.989
Pre-COMPASS – Algebra [1]	10	20.50		6	18.83		0.95	.361
Post-Compass - Pre-Algebra [2]	4	37.50		7	30.57		1.47	.176
Post Compass - Algbra [2]	10	38.40		12	22.00		6.80	.001
Mean Quiz Score- Algebra	11	39.45		12	24.97		1.97	.062
Mean Revision Score	11	88.39		12	77.26		2.69	.014
Mean Periodic Exam Score	11	56.54		12	33.40		2.96	.007
Pass rates for the COMPASS	11		(48%) Passed	12		(52%) Failed		

Note. [1]Some of the pre COMPASS scores were not available from the different colleges. [2] Students only had to retake that section of the COMPASS that they failed.

The data in Table 1 indicate that there were no differences in the pre COMPASS scores for the students who passed the course when compared to the pre COMPASS scores for students who failed the course, M = 26.90 vs. M = 26.86 for the pre COMPASS pre-algebra scores for the passing and failing groups respectively, t =. 014, p=.989, and M =20.50 vs. M = 18.83 for the COMPASS algebra scores for the students passing and failing the course respectively, t = .953, p=.361.

Students' academic progress in the program was tracked using four measures, (1) their mean quiz scores, (2) their periodic examination scores, and (3) their scores on the quiz reflection and revision forms (4) their pre-algebra and algebra scores on the post-test COMPASS. As reported in Table 1 the passing group exceeds, or almost exceeds, the failing group on the four program measures. There is a marginal statistical difference in the overall mean quiz scores for the two groups, M = 39.45 vs. M = 24.97 for the passing and failing groups respectively, t = 1.97, p = .06. There is a statistically significant difference in the mean revision scores for the two groups, M = 88.39 vs. M = 77.26 for the passing and passing student groups respectively, t = 2.69, p= .014. There is also a statistical difference in the mean scores earned by the two groups on the three periodic examinations, M = 56.54 vs. M = 33.40 for the passing and passing groups respectively, t = 2.96 p = .007. Finally, as expected, those students who passed the course had higher scores on the algebra section of the post- COMPASS examination, M= 38.40 vs. 22.00 for the passing student group and failing student group respectively, t = 6.80, p = .001. There was no difference in the pre-algebra scores for the two groups. We believe that this lack of significance is a consequence of the small number of students who were required to retake this portion of the COMPASS. We would also conclude that

 ISSN 2094-1420

these results suggest that it is the students' active participation in the self-reflection and revision process that significantly contributes to better academic outcomes, as reflected in their scores on periodic exams.

Implicit in these outcomes is that successful students are putting in sufficient 'time on task,' a behavior that we view as one reflection of their engagement, as well as their motivation and attitude. Students who passed the course completed a mean of 5.3 reflection and revision forms vs. a mean completion rate of 4.1 reflection and revision forms for those students who failed the course, $t = 2.20$, p=.04.

Eighty-two percent of the students who passed the course adhered to the attendance policy and 50% of the students who did not adhere to the attendance policy passed the course, $\chi 2 = 1.35$, n.s.(continuity correction).

These results parallel those of Zimmerman, Moylan, Hudesman, White, and Flugman (2011) who found that within the SRL classes those students who completed more reflection and mastery learning forms also did better than the less engaged students. We believe that despite the small number of students in this program, there is some support for a relationship between the students' level of engagement and their academic outcome.

At the end of the course all 23 students completed a short six question anonymous survey in which they shared their reactions to the program. The survey questions and tallies of the student responses are described in Table 2.

We believe that the tallies in Table 2 indicate that students had very positive reaction to the SRL developmental mathematics course; this despite the fact a majority of the students did not pass the course and most of these students had reported negative experiences in their prior mathematics courses.

Discussion

The purpose of this demonstration project was to implement an SRL program with formative assessment and mastery learning features with special program students who had previously been unsuccessful in passing the COMPASS examination – with most of these students failing the course on multiple occasions. Most of these students reported on their previous negative experiences which left them with poor expectations, and thus poor levels of engagement and motivation. A major focus of the program was to create a structure that optimized the students' engagement in the program's activities including attendance, using feedback from their daily quizzes as a starting point to improve their learning activities, e.g., by working on their self-reflection/mastery learning forms, going to tutoring, etc.

 ISSN 2094-1420

Table 2
Student Responses to the End-of-the-Course Survey

Survey Question	Positive Responses	Neutral or Negative Responses	Sample Student Comments
1. How would you rate your experience in this program compared with other college mathematics courses that you have taken?	22	1	1.It has been the best mathematics class – - - encouraged me to follow through with the (program) steps and improve in other subjects and everyday life
2.Compared to other mathematics courses how do you feel about the use of quiz format where you make pre and post judgments	23	0	1. You can see how you felt before and after and if your confidence was too high 2. A very sweet idea. It tells me where I need help
3.Compared to other mathematics courses how do you feel about the use of the revision form	20	3	1. I love/hate the revision form. Makes me realize that I make careless errors. 2. Writing out the steps helps me remember how to do it in the future.
4.Compared to other mathematics courses how do you feel about the use of tutoring	22	`1	There were a large number of 'It's great' comments from students
5.The part of the program you liked most, describe	23		Some of the most cited positive parts of the program included: the revision process, everyday quizzes, and tutoring.
6.The part of the program that could use some improvement	Nothing (16)		Some of the suggestions included requests for more quizzes, and add an additional day of classes.

Program results indicated that there was a difference in academic outcomes depending upon the students' level of engagement. Students, who engaged in the reflection/mastery learning process, were more likely to have successful academic outcomes compared to students who were less engaged. As indicated, these results are in keeping with those reported by Zimmerman, Moylan, Hudesman, White, and Flugman (2011) who found that within this SRL course, students who were more engaged in the revision process were more likely to pass the course and COMPASS examination than students who were less engaged.

The students' responses to the survey indicated that they thought the SRL program created a positive environment for learning. Even though the surveys were unsigned, it was clear that the overwhelming majority of all students, i.e., those who passed the course as well as those who did not pass the course, found the program to be a positive educational experience. This point was well illustrated in

 ISSN 2094-1420

the students' response to the last question which asked them how the program might be improved. Those students who did make suggestions often indicated that they would like to see additional class time and additional quiz work. We believe that this type of student response is reflective of their engagement in the course, regardless of whether they passed the course or not.

While implementing the program, the issue of student engagement became more complicated. As we indicated earlier, the original attendance policy stipulated that anyone who missed more than two classes would be dropped from the program. However, the program staff did, in fact, allow students to continue after two absences. It seemed to us that even many of the students with excessive absences were genuinely interested in the program against the backdrop of very difficult personal and family challenges, e.g. the hospitalization of a family member, or having a work schedule shifted so that they had to work all night before coming to class in the morning. Under the circumstances, we wonder whether students who exceeded the absence limit were better served by barring them from continuing or whether they should be allowed to continue coming to class. In reviewing the overwhelmingly positive responses from all of the program students, we would suggest that even the unsuccessful students derived some benefit from their program experience.

Study limitations and suggestions for future research

The main purpose of this paper was to describe an SRL program with formative assessment and mastery learning features and how it could be implemented with developmental mathematics students. Given the small number of students in this program there is an obvious concern about the analysis of the data, especially since it was not possible to construct a suitable comparison group of special program students. Furthermore, it would be important to further clarify the connection between students' level of engagement and their motivation/attitude. Perhaps the use of the LASSI (2012) might be helpful in establishing such a relationship.

Finally, it should be noted that new instructors are often 'put off' by the extra time required when implementing the SRL program. They are concerned about having enough time to complete the regular course requirements, let alone the time commitment required to implement the special features in our program. Our experience has been that there is indeed an 'upfront' time issue at the start of the semester; however, as students become more efficient learners, they make up the time during the semester. In fact, we have never encountered a situation where an instructor has reported not having enough time to complete the course curriculum. Of course, any modifications that can make the SRL program more effective would be important. For example, Hudesman, Carson, Flugman, Clay, and Isaac (2011) reported some success in using a tablet PC to administer the quizzes and provide immediate feedback to both the student and instructor.

 ISSN 2094-1420

There are significant issues that must still be addressed in the future development and implementation of the SRL program; however, we believe that when this work is viewed as part of a larger programmatic initiative, e.g., with the work of Zimmerman, Moylan, Hudesman, White and Flugman (2011), Hudesman, Crosby, Flugman, Isaac, and Everson (2012), and others, there is continued support for the use of the SRL, formative assessment, and mastery learning approach to assist students in becoming more engaged in as well as in improving their mathematics achievement.

References

Achieve (2010). *American Diploma Project End-of-Course Exams: Annual report 2010*. On-line [available] www.achieve.org/files/AchieveADPEnd-of-CourseExams2010AnnualReport.pdf.

ACT (1997). Computer-Adaptive Placement Assessment and Support System in mathematics (COMPASS). *American College Testing Manual*. Iowa City, IZ: ACT Inc.

ACT (2006). *COMPASS Reference Manual*. Iowa City, IA.

Bailey, T. (2009). Challenges and opportunities: Rethinking the role and function of developmental education in community colleges. *New Directions for Community Colleges, 145*, 11-30.

Black, P., & Wiliam, D. (1998a). Assessment and classroom learning. *Assessment in Education: Principles, Policy & Practice, 5*, 7-71.

Black, P., & Wiliam, D. (1998b). Inside the black box: Raising standards through classroom assessment. *Phi Delta Kappan, 80*, 139-148.

Black, P., & Wiliam, D. (2009). Developing the theory of formative assessment. *Educational Assessment, Evaluation and Accountability, 21*(1), 5-31.

Blank, S., Hudesman, J., Morton, E., Armstrong, R., Moylan, A., White, N., & Zimmerman, B. J. (2007). *A Self-Regulated Learning Assessment System for Electromechanical Engineering Technology Students*. Published in the Proceedings of the National STEM Assessment Conference, October 19-21 2006, Washington D.C.. Drury University and the National Science Foundation.

The Carnegie Foundation for the Advancement of T. (2009). *Developmental Mathematics*. On-line [available] www.carnegiefoundation.org/problem-solving/developmental-mathematics

CUNY Office of Institutional Research (2012). *CUNY.edu/about/administrative/offices/ira/data-book/seel-college-discovery.html.*

Grant, A. M. (2003). The impact of life coaching on goal attainment, metacognition, and mental health. *Social Behavior and Personality*, *31*(3), 253 – 264.

Grant, A. M. (2008). Personal life coaching for coaches-in-training enhances goal attainment, insight, and learning. Coaching. *An International Journal of Theory, Research, and Practice, 1*(1) 54 -70.

 ISSN 2094-1420

Heritage, M. (2010). *Formative assessment and next-generation assessment systems: Are we losing an opportunity?* Report prepared for the Council of Chief State School Officers.

Hudesman, J., Carson, M., Flugman, B., Clay, D., & Isaac, S. (2011). *The computerization of the self-regulated learning assessment system: A demonstration program in developmental mathematics*. A paper presented at the 9th Annual Meeting of the Education and Information Systems, Technologies, and Applications (ESTIA), Orlando, Fl.

Hudesman, J., Carson, M., Flugman, B., Clay, D., & Isaac, S. (2011). The computerization of the self-regulated learning assessment system: A demonstration program in developmental mathematics*. The International Journal of Research and Review*, (6) 1-18.

Hudesman, J., Zimmerman, B., & Flugman, B. (2010). *The Replication and Dissemination of the Self-Regulated Learning Model to Improve Student Performance in High Schools, Two-Year, and Four-Year Colleges: FIPSE P116B060012*. New York: City University of New York.

Sadler, D. R. (1989). Formative assessment and the design of instructional systems. *Instructional Science,* 18, 119-140.

Tobias, S., & Everson, H. T. (2002). *Knowing what you know and what you don't know*. College Board Report (2002-04). College Board, N.Y.

Weinstein, C. E., Schulte, A. C., & Palmer, D. R. (2012*). Learning and Study Strategies Inventory*. H & H Publishing Co. Clearwater, Fl.

Zimmerman, B. J. (2000). Attaining self-regulation: A social cognitive perspective. In M. Boekaerts, P. Pintrich, & M. Zeidner (Eds.), *Handbook of Self-regulation* (pp. 13-39). San Diego, CA: Academic Press.

Zimmerman, B. J. (2002). Achieving self-regulation: The trial and triumph of adolescence. In F. Pajares & T. Urdan (Eds.), *Academic motivation of adolescents, 2,* 1-27.

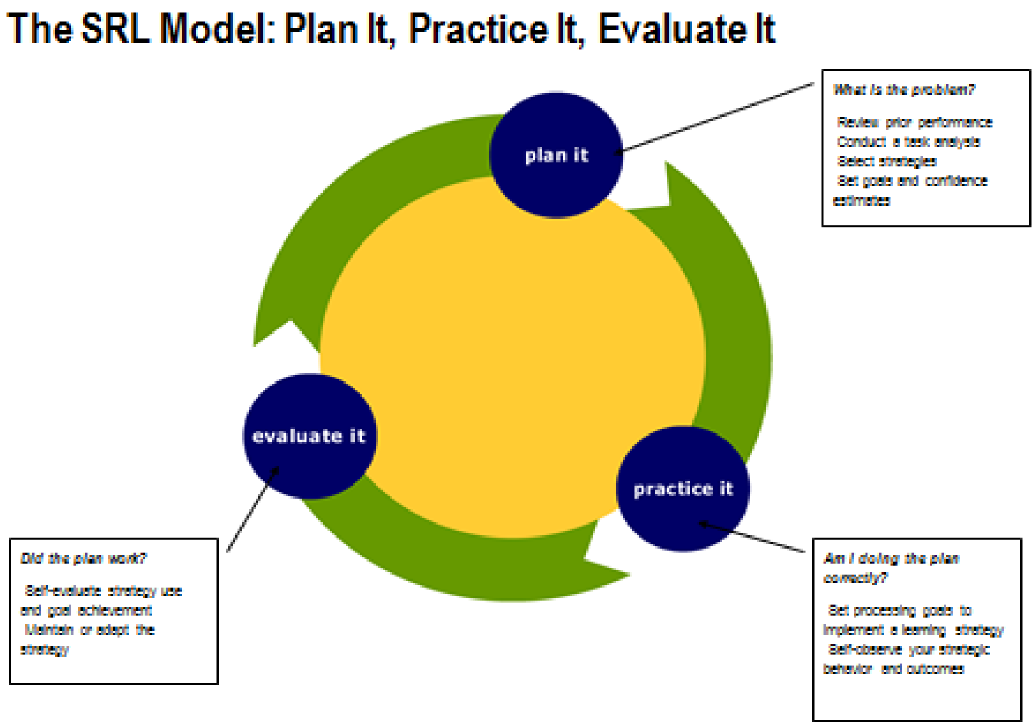
Zimmerman, B. J. (2006). Integrating classical theories of self-regulated learning: A cyclical phase approach to vocational education. In D. Euler, G. Patzold, & M. Lang (Eds.), *Self-regulated learning in vocational education* (pp. 7-48). Stuttgart, Germany: Franz Steiner Verlag.

Zimmerman, B. J., & Bandura, A. (1994). Impact of self-regulatory influences on writing course attainment. *American Educational Research Journal, 31*, 845-862.

Zimmerman, B. J., Moylan, A. R, Hudesman, J., White, N., & Flugman, B. (2011). Enhancing self-reflection and mathematics achievement of at-risk urban technical college students. *Psychological Test and Assessment Modeling,* 53(1), 108-127.

 ISSN 2094-1420

Figure 1



Hudesman, White, Moylan, and Crosby (2005)

 ISSN 2094-1420

Appendix A: A Sample EFAP Mathematics Quiz

Name: ______________________ Date: ____________ Quiz #: __________

Predicted Score: ____________ Preparation Time: ____________ mins.

Before solving each problem, how confident are you that you can solve it correctly?	REMEMBER! Show all your work. Simplify all your answers.	After you have solved each problem, how confident are you that you solved it correctly?
0% 25% 50% 75% 100%	1. Factor completely: $10x^2y^2 + 4xy^3 - 2y =$	0% 25% 50% 75% 100%
0% 25% 50% 75% 100%	2. Divide: $\frac{8a^2b^2 - 12a^3b^2c + 4ab^2}{4ab^2}$	0% 25% 50% 75% 100%
0% 25% 50% 75% 100%	3. Express answer in scientific notation: a) 6700000 b) 0.000015	0% 25% 50% 75% 100%
0% 25% 50% 75% 100%	4. Compute and express in scientific notation: $\frac{(3.6 \times 10^{-5})(6 \times 10^{3})}{1.2 \times 10^{5}}$	0% 25% 50% 75% 100%
0% 25% 50% 75% 100%	5. Multiply: $(5x - 3)^2$	0% 25% 50% 75% 100%

 ISSN 2094-1420

Appendix B: A Sample EFAP Reflection/Revision Form

SRL Math Revision Sheet, Quiz #____ Item # ____
Student: ______________________ **Date: _______**
Instructor: ______________________

Now that you have received your corrected quiz, you have the opportunity to improve your score. Complete all sections thoroughly and thoughtfully. Use a separate revision sheet for each new problem.

PLAN IT 8pts

1. a. How much time did you spend studying for this topic area? _______

b. How many practice problems did you do in this topic area ____________________________in preparation for this quiz?

(circle one) 0 – 5 / 5 – 10 / 10+

c. What did you do to prepare for this quiz? (use study strategy list to answer this question)

2. After you solved this problem, was your confidence rating too high (i.e. 4 or 5)? yes no

3. Explain what strategies or processes went wrong on the quiz problem.

PRACTICE IT 8pts

4. Now re-do the original quiz problem and write the strategy you are using on the right.

Definitely not confident	Not confident	Undecided	Confident	Very confident

5. How confident are you now that you can correctly solve this similar item?

1 2 3 4 5

6. Now use the strategy to solve the alternative problem.

4pts

7. How confident are you now that you can correctly solve a similar problem on a quiz or test in the future?

1 2 3 4 5

4pts