Self-efficacy, Motivational Email, and Achievement in an Asynchronous Mathematics Course

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Doctor of Philosophy in
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Abstract

This study investigated the effects of motivational email messages on learner self-efficacy and achievement in an asynchronous college algebra and trigonometry course. A pretest-posttest control group design was used. Of the 196 initial participants randomly assigned to treatment groups, 125 participants with an average age of 18.21 years completed the study. The final control and experimental groups consisted of 57 (n=17 male, n=40 female) and 68 (n=14 male, n=54 female) participants respectively. Self-efficacy to learn mathematics asynchronously (SELMA) was measured before the treatment was administered. Email messages designed to be efficacy enhancing were sent to the experimental group weekly for 4 weeks. The control group was sent email messages designed to be neutral with respect to self-efficacy weekly for 4 weeks. SELMA and math achievement were measured after the email messages were sent in week 4. Analysis of covariance was performed using the pretest SELMA measure as a covariate to detect post-treatment differences in SELMA between the control and experimental groups. No significant differences were detected at the 0.05 alpha level. Paired-sample t-Tests revealed significant increases in SELMA for both the control and experimental groups over the treatment period. Linear regression analysis revealed a weak positive relationship between SELMA and math achievement. The findings are discussed in the context of the related literature and directions for future research are suggested.
Acknowledgements

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Distance education is now commonplace in most institutions of higher learning, and the number of courses offered at a distance is on the rise. In a recent report by the United States Government National Center for Education Statistics (NCES), distance education was defined as “education or training courses delivered to remote (off-campus) sites via audio, video (live or prerecorded), or computer technologies including both synchronous (i.e., simultaneous) and asynchronous (i.e., not simultaneous) instruction” (NCES, p. 1). The authors of that study report that during the 12-month 2000-2001 academic year 56 percent of all two- and four-year Title IV eligible institutions offered distance education courses and 12% of all institutions indicated that they planned to start offering distance education courses in the next three years. During the reported academic year, it is estimated that 3,077,000 students were enrolled in distance education courses offered by 2-year and 4-year institutions. The Internet is the most commonly used technology with which to deliver distance education. The NCES also reported that during the 2000-2001 academic year, 90% of institutions offering distance education courses delivered the courses via the Internet. Additionally, the NCES reported that of the institutions that offered distance education courses or that planned to offer distance education courses in the next 3 years, 88% indicated plans to start using or increase the use of the Internet as their means of delivery for those courses.

The millions of students enrolled now or who will enroll in distance education programs may find the courses to be attractive for many reasons including the asynchronous nature of such offerings. However, once enrolled, the students may experience a sense of isolation with regard to the course. The standard motivating forces active in traditional classrooms such as group
pressure, a familiar learning situation, and social factors are often absent in distance education programs (Zvacek, 1991). But, in a discussion of motivation in cyber learning environments, Keller (1999) asserts that the motivational requirements of learners have remained stable over time. Hence, special attention must be given to motivational requirements of students in distance learning environments. Zvacek (1991) stresses that the role of motivation in distance education cannot be overstated.

Fundamental to motivation is the concept of self-efficacy, which was introduced by Albert Bandura (1977). “Perceived self-efficacy refers to beliefs in one’s capabilities to organize and execute the courses of action required to produce given attainments” (Bandura, 1997, p. 3). Thus, self-efficacy beliefs influence students’ behavior by influencing the decisions of which tasks in which to engage, what level of effort they will expend, and how long they will persevere in the face of difficulty. Every teacher wants his or her students to work through challenging educational situations and to perform well. Therefore, teachers should be concerned about the self-efficacy perceptions of their students.

Research has shown that self-efficacy is a strong predictor of academic achievement in traditional classrooms, across various domains of learning. Mathematics self-efficacy has received attention in the research literature since the early 1980s, and results have consistently shown that it is an important construct in math achievement. Quantitative skills have become necessary for many career choices due to an increased reliance on technology and consequently mathematics and mathematics related skills are important for learners to acquire.

Research on how students’ self-efficacy beliefs affect their performance in web-based courses is just beginning (Miltiadou & Savenye, 2003) and research on math self-efficacy in online environments is nonexistent. Many universities are moving toward asynchronous delivery
of introductory mathematics courses (The Learning MarketSpace, 2005). With the growing numbers of online course offerings and learners enrolled in those courses, these are gaps in the research literature that must be addressed. In what follows the power of self-efficacy in academic endeavors will be demonstrated in general and with regard to the learning of mathematics. Research on self-efficacy in online learning environments will be discussed and suggestions for future research will be offered. In particular, the case will be made that email is a possible low-cost strategy for increasing the self-efficacy of online learners. Chapter 2 begins with a review of the relevant literature regarding self-efficacy and concludes with the statement of the research questions to be addressed in the proposed study. Chapter 3 details the proposed methods to investigate those research questions. Results of data analyses are presented in Chapter 4. Chapter 5 is a discussion of the results, study limitations, and directions for future research.
Chapter 2: Review of Literature

This literature review begins with the historical development of self-efficacy theory and an overview of the theory itself. Following that, the specific areas of academic self-efficacy, self-efficacy for mathematics, self-efficacy in asynchronous learning environments, and assessment of self-efficacy are discussed. There has been relatively little research conducted on self-efficacy in asynchronous learning environments. Research on self-efficacy and online learning, self-efficacy for the use of computers in instructional situations, and the limited amount of research involving web-based instruction are addressed to capture the essence of self-efficacy for online asynchronous learning environments. Research on self-efficacy in academic environments is strongly connected to the literature involving self-regulation. Therefore, a brief review of the research involving self-regulation in online learning environments is included.

A Brief History of Self-efficacy

The construct of self-efficacy has a relatively brief history. Albert Bandura (1977) proposed self-efficacy as a conceptual framework to explain and predict whether or not one will choose to engage in an activity, if engaged, how much effort will be expended, and how long one will persevere in the activity. Bandura’s 1977 work was a shift in psychological thinking for the time, but he was certainly not the first person to consider the idea of self as an important aspect of one’s being.
The self in American psychology

Concepts of the self in psychological thinking have come and gone from prominence through the years. Pajares and Schunk (2002) credit Socrates, Plato, and Aristotle as early theorists of the self, where self was defined as one’s soul. William James’ (1891a; 1891b) work on the self in his two volume *Principles of Psychology* is credited by Pajares and Schunk as the roots of theorizing on the self in American psychology. Pajares and Schunk also list James as one of the first writers to use the term self-esteem in his 1896 work, *Talks to Teachers*. Other early theorists who contemplated the self were Charles Hooten Cooley (1902) with his looking-glass self and Sigmund Freud (1923) with his id, ego, and superego (Pajares & Schunk, 2002).

The early theorists studying the importance of the self were overshadowed by the behaviorist movement, which was formally introduced to American psychology by John Watson (1913). Watson took issue with the introspective nature of psychology prior to behaviorism and the lack of rigor associated with its measures. He was a champion of observable and measurable behavior. Writing of behaviorism Watson states “Introspection forms no essential part of its methods” (p. 158), “The time seems to have come when psychology must discard all reference to consciousness; when it need no longer delude itself into thinking that it is making mental states the object of observation.” (p. 163), and “I believe we can write a psychology, define it as Pillsbury, and never go back upon our definition: never use the terms consciousness, mental states, mind, content, introspectively verifiable, imagery, and the like.” (p. 166). Watson’s writing influenced and the self was neglected by the field of psychology for some time.

The study of the self came back into focus in the 1950s with the work of Abraham Maslow (1954) and what is termed humanistic psychology. A product of this movement was an interest in self-esteem. This movement, however, was hindered due in part to the fact that “the
association between self-esteem and its expected consequences were mixed, insignificant, or absent” (Pajares & Schunk, 2002, p. 12). Interest in concepts of the self faded for a time once again, but it would resurface in the 1980s.

The arrival of the computer in the 1980s is commonly credited with influencing the shift from the humanistic to cognitive view of psychology (Bandura, 2001b; Driscoll, 2000; Pajares & Schunk, 2002). In cognitivism there is a focus on internal, mental events. The mediating variable between the environment and one’s behaviors is the learner’s information processing system, which focuses on memory, encoding and decoding information, and human thinking. This focus on the self, however, fell out of vogue as parents and educators became concerned with academic standards and a lack of focus on the basics in education. Pajares and Schunk conclude, “as a consequence, research on the self and self-beliefs did not merely wane, it was viewed as antithetical to sound educational understandings” (p. 13). However, Pajares and Schunk remark that “the self has once again become the focus for educational psychology research and practice on academic motivation” (p. 13).

The fluctuations in psychological thinking discussed above can be seen easily by reviewing the topics covered in the chapters on motivation in the Encyclopedia of Educational Research (Ball, 1982; Marx, 1960; Weiner, 1969; 1992; P. T. Young, 1941, 1950). The Encyclopedia of Educational Research has been published six times since 1941 at approximately 10-year increments. Each edition has chronicled the previous decade’s educational research. See Table 1 for a summary of the changes over the years. The emergence of the self can be seen in the 1980 edition as self-esteem and self-efficacy in the 1992 edition. The roots of self-efficacy theory also can be observed in Table 1. Those roots will now be detailed
Table 1

*Topics from Motivation Chapters in the Encyclopedia of Educational Research, 1941 – 1992*

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Precursors to Self-efficacy

“Three conceptual systems have converged in pointing out that that self-perception of ability and the belief that I can or I cannot is a central determinant of motivation. These conceptual systems are labeled attribution theory, self-efficacy theory, and learned helplessness” (Weiner, 1992, p. 863). It is self-efficacy that is the focus of the current discussion. Purposive behaviorism, level of aspiration, locus of control, and achievement motivation foreshadow Bandura’s (1977) self-efficacy. These precursors will be discussed chronologically by their development, beginning with purposive behaviorism.

Purposive Behaviorism

There were hints of the shift from a behaviorist approach to motivation to a cognitive approach in Tolman’s (1967) work from 1932 on purposive behaviorism. Tolman went beyond the stimulus-response associations of behaviorism and stressed goal-directed behavior. He observed in his work with rats that strongly desired goals resulted in improved speed and performance compared to the use of less desired goals. Tolman also recognizes expectancy. When presented with specific stimulus, an organism will exhibit a condition Tolman refers to as means-end-readiness. For example, an organism, in Tolman’s case a rat, is hungry (biological stimulus). It will demonstrate the behavior of searching for food (the means-end-readiness) and, upon finding the food (the goal-object), will exhibit a particular means-end-expectation. The means-end-expectation is a particular behavior associated with type of goal-object expected. Continuing with the example of the hungry rat, the means-end-expectation is the behavior of interacting with the food in a manner consistent with the food discovered in previous food-
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searching situations. More simply, even rats form expectancies about what will happen, if they perform certain behaviors.

Tolman uses the terms *purpose* and *cognitive* in his work, but he plainly remarks that he is using the terms in a neutral and objective sense. He summarizes “Purposive Behaviorism is a molar, not a molecular, behaviorism, but it is none the less a behaviorism. Stimuli and responses and the behavior-determinants of responses are all that it finds to study” (p. 418). The use of the term *molar* here is fundamental to Tolman’s purposive behaviorism. He considers the behaviors (e.g. a conversation between two friends or a person reading) as more than the physiological processes that produce the behaviors, but as responses with identifying characteristics of their own. A molecular view of behaviorism, like that of Watson (1913), defines behavior strictly in terms of the underlying physiological processes. Tolman’s goal-directed behavior is similar to what Lewin and his colleagues termed, *level of aspiration*.

**Level of Aspiration**

*Level of aspiration* represents another transition from behaviorism to cognitive approaches to motivation. *Level of aspiration* is the goal-striving behavior which occurs within a range of difficulty (Lewin, Dembo, Festinger, & Sears, 1944). To illustrate *level of aspiration* a hypothetical sequence of events will be used. Suppose a person is given a basketball, a basketball court, and a basketball goal and is asked to attempt to make at least two goals. A demonstration of a basketball goal will be provided, if necessary. The person will attempt a goal. If the goal is not made, the person will adjust the distance from the goal, stance, grip on the ball, and try again. If the person does make the goal, no adjustment may be necessary and the person will attempt a second goal. This process will continue until the person makes the
requested two goals, or decides to leave the activity. This sequence of events can be outlined as follows:

1. Past performance or similar experience
2. Setting of level of aspiration
3. New performance
4. Reaction to level of attainment

How does one set the level of aspiration? Lewin et. al (1944) considered research on level of aspiration and found that it can be linked with three factors: seeking of success, avoiding failure, and cognitive probability judgment. A subject will determine level of aspiration in a given situation so that success is perceived to be likely. Success may be determined by personal goals. For instance, in the basketball example above, a subject may not feel that it is possible to make the requested two baskets, but may define making one basket a success. The level of aspiration also is dependent on a subject’s peer or cultural group performance or performances of other cultural groups. This is easily observed in a group of young males who wish to perform better at a task (i.e. the basketball example) than a group of young females. A male may easily decide that performing as well as the average male is acceptable, but a performance less than the best female performance may be unacceptable.

What are the reactions to achieving or not achieving the set level of aspiration? There is an obvious feeling of success or failure when a goal is met, exceeded, or not met at all. However, these feelings differ for each individual. If one meets or exceeds the set level of aspiration, then a feeling of success is likely. However, if the level of aspiration is not met, a person will typically make rationalizations to avoid a feeling of failure, continue to the activity with the hope of improvement, or stop the activity. If the activity is attempted again, the level of
aspiration may be lowered or raised depending on the last performance. Rationalizations may include attributing the failure to causes external to one’s self such as sickness or malfunctioning equipment, or changing the perspective of the performance so that it can be seen as a success.

Level of aspiration is linked with three elements: seeking of success, avoiding failure, and a judgment of probability. Behaviorism is definitely seen with the reward and punishment view of success and failure, but the inclusion of a cognitive judgment such as probability of success is a clear step away from behaviorism.

The works of Tolman and Lewin influenced John W. Atkinson. Atkinson combined ideas from Tolman and Lewin to develop his theory, *achievement motivation*.

*Achievement Motivation*

John W. Atkinson (1957; 1964) built his achievement motivation model on Tolman’s (1967) construct of expectancy and the construct of level of aspiration (Lewin et al., 1944).

The theory of achievement motivation attempts to account for the determinants of the direction, magnitude, and persistence of behavior in a limited but very important domain of human activities. It applies only when an individual knows that his performance will be evaluated (by himself or by others) in terms of some standard of excellence and that the consequence of his actions will be either a favorable evaluation (success) or an unfavorable evaluation (failure). It is, in other words, a theory of *achievement-oriented* performance.

(Atkinson, 1964, p. 240-241)
Atkinson’s model is comprised of three components: motives, expectancy, and incentive. Atkinson (1957) defines motive as “a disposition to strive for a certain kind of satisfaction” (p. 360). Motives may be classified into two groups: appetites, which are aimed at maximizing satisfaction; and aversions, which aim toward minimizing pain. These appetites and aversions can be describing physical needs such as the need to find food or to avoid pain, but also can be used to describe the cognitive traits of achievement success or avoidance of embarrassment due to failure. Atkinson’s expectancy is a cognitive anticipation of a particular consequence following the performance of some act, and incentive is “the relative attractiveness of a specific goal that is offered in a situation, or the relative unattractiveness of an event that might occur as a consequence of some act” (p. 360).

Atkinson’s theory considered one’s motivation to be a multiplicative function of these three components, motivation = motive x expectancy x incentive. He viewed expectancy as a probability of success ranging from 0 to 1. Incentive was assumed to be a linear function of expectancy modeled as incentive = 1 − expectancy. Note that events for which there is a low probability of success will have higher incentive values. In other words, there is not as much incentive for a person to perform an easy task (a task for which the expectancy to succeed is high) as there is to perform a somewhat more difficulty task. Given the relationship between expectancy and incentive, one can see that the greatest motivation will occur when expectancy, and, therefore, incentive are of intermediate value (expectancy = 0.5). When one considers motive, the third factor in the model, it can be seen how decisions are made about the tasks in which to engage in order to maximize motivation. A person who has a motive to succeed, an appetite, should choose tasks with an intermediate expectation of success. However, if a person
is motivated to avoid failure, that person should choose to engage in tasks of either great
difficulty or little difficulty.

Bernard Weiner (1972) remarked, “Achievement theory is the most precise of the
‘cognitive’ conceptions of action, yet remains generally unconcerned with mental events” (p. 269). Achievement theory considers individuals’ perceptions of success and failure along with
perceptions of probability for success, but the theory does not address how these concepts are
formed. Perceptions of success and failure are key elements in the work of Rotter on locus of
control, which is the last theoretical precursor to self-efficacy theory.

*Locus of Control*

Rotter (1966) proposed that changes in expectancy are predictable from whether or not a
person perceives rewards to be contingent upon his or her own behavior. If a person perceives
that a reward is dependent on his or her own behavior or relatively permanent characteristics, the
person is said to have an internal locus of control. If the perception is that a reward is dependent
on luck, chance, or the assistance of others, the person is said to have an external locus of
control. Rotter proposed that these perceptions guide what kinds of attitudes and behaviors
people adopt. For example, a student with an external locus of control who performs well on a
test might assume that the good performance was due to an *easy* test. Whereas, a student with an
internal locus of control might assume that a good performance on a test was due to the hours
spent studying for the test. “Investigations of differences in behavior in skill and chance
situations provide relatively clear-cut findings” (Rotter, p. 8). Past experience is relied on less
when a learner perceives a task as controlled by random or external conditions and an internal
locus of control is related to greater achievement motivation.
Summary

The work of Tolman (1967), Lewin (1944), Atkinson (1957, 1964), and Rotter (1966) dealt with the construct of expectancy. This was a change from the traditional behaviorist view of ignoring the cognitive component of the subjects and reducing all behaviors into the physiological elements of stimuli and responses. Interestingly, Tolman’s work used rats as subjects, but the experiments of Lewin and Atkinson involved human subjects. This change is one indicator of the transition from the mechanistic view to a cognitive view of psychology through the recognition that the human mind has influence over decisions and motivation. These early models recognized the individual’s perceptions of the ability and desire to do a task combining those beliefs to describe one’s motivation to perform a task. Cognitive terms are used in these theories, but the only cognitive structures considered are path to a goal and the expectancy of achieving the goal. They consider that prior experience is used to form beliefs, expectancies, of anticipation toward a final goal, but they do not consider internal representations of human thinking.

Of these precursors to self-efficacy, it appears as though Rotter’s (1966) work has the most similarity to that of Bandura (1977) which will be discussed next. Bandura expands on Rotter’s expectancy concept, which was a belief about the reinforcement in a situation. Rotter was principally interested in action-reinforcement relationships. Bandura considers a similar construct, outcome expectations, but includes an expectancy about one’s self-efficacy expectations, which marks the transition from behaviorism toward a cognitive view of psychology.
Self-efficacy

Bandura introduced self-efficacy in his 1977 paper *Self-efficacy: Toward a Unifying Theory of Behavioral Change*. In that paper, Bandura makes the assumption that psychological procedures, such as the cognitive appraisals of observations or other stimuli, serve as an instrument to create or strengthen one’s self-efficacy. He also posits that self-efficacy is derived from four primary sources: performance accomplishments, vicarious experience, verbal persuasion, and physiological states. Bandura (1977) considers two expectancies: efficacy expectations and outcome expectations. An outcome expectancy is a person’s estimate that a certain outcome can be obtained as a result of a certain behavior. An efficacy expectation is the belief that the required behavior can be successfully executed to produce a desired outcome. Transitioning from the behaviorist beliefs of his training, Bandura asserts that social learning theory “emphasizes the informative function of physiological arousal” (Bandura, 1977, p. 199) and that the cognitive evaluation of these arousals determines the magnitude and direction of one’s motivation to action. After his introduction of the theory, Bandura (1982) reviewed self-efficacy research and concluded that it has substantial explanatory power in varied domains such as health rehabilitation, phobias, physical stamina, addiction, achievement strivings, and career choice. He continued his work on self-efficacy, eventually collecting his ideas in his more general social cognitive theory (Bandura, 1986) which suggests that an individual’s cognitive factors, behavior, and environment are all connected through a model of reciprocal determinism.

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
The influence of each component of Bandura’s triadic reciprocality varies in different circumstances. For example, if a person has low level of self-efficacy in a certain situation, then that person is less likely to be able to exert control over the environment than when the person is in a situation where a high level of self-efficacy is present.

Bandura’s (1982) conclusions regarding the explanatory power of self-efficacy have been validated by many studies. Meta-analyses of self-efficacy research in the domains of academic achievement (Multon, Brown, & Lent, 1991), group functioning (Gully, Incalcantara, Joshi, & Beaubien, 2002; Stajkovic & Luthans, 1998), health (Holden, 1991), and sports performance (Moritz, Feltz, Fahrbach, & Mack, 2000) are consistent in finding that self-efficacy beliefs are significant contributors to motivation and performance.

There have been those in disagreement with Bandura’s social cognitive theory and self-efficacy. Powers (1991) argued that Bandura’s (1989) work is explained by the older control theory and took issue with Bandura’s use of what Powers termed natural language. Powers contends that motivation is explained by control theory’s negative feedback loop where one interprets the environment and takes action to close the gap between an internal representation of the environment and what was received via the feedback loop. Bandura and Locke (Bandura, 1991; Bandura & Locke, 2003) disagree with this mechanistic view of motivation, arguing that it does not account for the variety of possible reactions to failed attempts at performance.
More recently, research (Vancouver, Thompson, Tischner, & Putka, 2002; Vancouver, Thompson, & Williams, 2001) has disputed the causal link of self-efficacy with performance. They claim their research demonstrates a negative relationship between self-efficacy and performance. Briefly, their conclusions are that as one’s self-efficacy for a task increases, effort will lessen, thus, performance will suffer. Vancouver and his associates (Vancouver et al., 2002; Vancouver et al., 2001) do not claim that their results are new, but do argue that their methods of analysis shed new light on this aspect of self-efficacy and call for more research to back their claims.

Bandura and Locke (2003) addressed both Power’s control theory and the results of Vancouver et al. (Vancouver et al., 2002; Vancouver et al., 2001), dismissing both. In a rather stern analysis of control theory Bandura and Locke write, “Control theory is rather barren psychologically. It has identified little in the way of new processes aside from the ones already known” (p. 93). As for the findings of Vancouver and his colleagues (Vancouver et al., 2002; Vancouver et al., 2001), Bandura and Locke cite nine large-scale meta-analyses as proof that self-efficacy does positively affect performance and they address conceptual, methodological, and interpretive problems with the works. Bandura (1997) also addressed the Vancouver et al. (Vancouver et al., 2002; Vancouver et al., 2001) claims of high self-efficacy resulting in diminished performance earlier when he wrote:

A good number become over complacent. They view themselves as highly efficacious in the meeting the challenge, they are too content with a near miss to mobilize the effort needed to do better. Folk wisdom cautions that too much confidence has deceived many a person. …. Motivation is perhaps best maintained by a strong sense of efficacy to
withstand failure, coupled with some uncertainty that is ascribed to the challenge of the task rather than to fundamental doubts about one’s abilities to put forth the effort needed to fulfill personal challenges. (p. 130)

One should not expect any scientific theory to go unchallenged so the cases listed above are not unexpected. Collectively, the research performed on self-efficacy has shown, across many domains (Gully et al., 2002; Holden, 1991; Moritz et al., 2000; Multon et al., 1991; Stajkovic & Luthans, 1998), that it is an important element of motivation. Self-efficacy is similar to the other expectancy-based concepts discussed earlier, but those concepts focused on outcome expectations. Bandura’s self-efficacy includes the outcome expectations, but also considers the cognitive aspect of efficacy expectations.

Now the specific domain of academic self-efficacy will be discussed. This area will be the general focus for the remainder of this paper. After a discussion of academic self-efficacy, the more specific topics of self-efficacy for mathematics and self-efficacy for learning online will be addressed.

Academic Self-efficacy

Academic self-efficacy refers to one’s confidence to perform successfully in academic endeavors. “The predictive power of self-efficacy beliefs on students’ academic functioning has been extensively verified” (Zimmerman & Schunk, 2003, p. 446). Research on self-efficacy in academic settings has focused on prior performance, modeling, goal setting, and attributional feedback. Each of these areas has been thoroughly investigated in connection with self-efficacy. The predominant finding is that students’ self-efficacy beliefs are significantly and positively related to academic performance.
Prior performance has proven to be an important element in students’ perceptions of self-efficacy. Self-efficacy beliefs, however, appear to be more than a reflection on prior performance. Several studies have shown that self-efficacy beliefs are formed by a cognitive weighting process using such factors as prior performance, self-perceptions of ability, effort expended, task difficulty, and the amount of assistance received (Bouffard-Bouchard, 1989; Schunk, 1982, 1983a, 1984; Zimmerman, Bandura, & Martinez-Pons, 1992). Hence, educators should focus on students’ perceptions of ability as well as their actual ability.

Early research on academic self-efficacy investigated the effect of modeling on self-efficacy. Brown and Inouye (1978) used male college students and studied the effect of observations of models solving anagrams. Subjects were given anagrams to solve after they judged their self-efficacy for solving such puzzles. Subjects were then told that they performed as well as a model, better than a model, or were given no competence feedback. A peer model was then observed having difficulty solving anagrams. After this observation subjects judged their self-efficacy again and were given more anagrams to solve. In this experiment there was a positive correlation between self-efficacy and persistence. Subjects who were told they were more competent than the model persisted for longer and judged their self-efficacy higher than students who were given no competence feedback. Subjects who were told they had performed as well as the model persisted for less time and judged their self-efficacy lower than the group that received no competence feedback. Zimmerman and Ringle (1981) studied the effect of adult models and statements of confidence for solving puzzles on children’s persistence and self-efficacy. The subjects judged their self-efficacy for solving a particular type of puzzle before and after observing an adult model working on the puzzle. Subjects who observed the model
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persist at solving a puzzle while making statements of confidence had higher self-efficacy than those that observed a model solving the puzzle while making pessimistic comments.

Modeling also was addressed by Schunk and Hanson (Schunk, 1981; Schunk & Hanson, 1985, 1989). In these studies it was again determined that self-efficacy is an accurate predictor of performance. Additionally, modeling was shown to be a valid method of increasing self-efficacy with peer models, resulting in the highest levels of self-efficacy and achievement.

Self-motivation through the use of academic goals has been shown to be an effective method of increasing academic performance. Self-efficacy plays an important role in the use of goals. One may classify goals as either proximal or distal. These descriptors classify the discrepancy between the current level of performance and the goal performance in terms of time or performance level. A proximal goal is a goal that is perceived to be attainable in a short period of time or with minimal improvement. A distal is a goal that is thought to be more long-term or is attainable through much improvement. Bandura and Schunk (1981) found that proximal goals produced learners who progressed rapidly in self-directed learning, achieved mastery of the content, and developed increased efficacy beliefs and intrinsic interest in the subject matter. Distal goals had no significant effects. In addition, self-efficacy was positively related to performance and intrinsic interest in the activities used in this study.

Path analysis was used by Zimmerman, Bandura, and Martinez-Pons (1992) to study the causal role of students’ self-efficacy beliefs and academic goals in self-motivated academic attainment. Their study used a sample consisting of 102 (50 male and 52 female) ninth- and tenth-grade social studies students. Students were surveyed on self-efficacy for self-regulated learning and self-efficacy for academic attainment as well as grade goals. The subjects’ parents were also surveyed to collect the grade goals they had for their children. Students’ perceived
self-efficacy for academic attainment was found to be predictive of both the final grade in the course and personal goals. In fact, the prediction of students’ academic achievement increased by more than 30 percent when perceived self-efficacy was added to the path models. Another important relationship revealed in this study was that the academic goals of parents were tempered by the children’s academic self-efficacy beliefs. Therefore, “efforts to foster academic achievement need to do more than simply set demanding standards for students. They need to structure academic experiences in a way that enhances students’ sense of academic efficacy as well” (Zimmerman et al., p. 673).

Attributions in the context of learning refer to ways in which learners attempt to understand their performances. Ability, effort, task difficulty, and luck are common attributions made by learners. Attributions about learning and performance are an important factor in the motivation to learn (Weiner, 1979). Attributional feedback was used in a series of experiments by Schunk (1981; 1982; 1983a; 1984) involving self-efficacy and elementary school children. Those studies demonstrated a noticeable improvement in performance as self-efficacy perceptions increased. In each of those experiments, students were provided with attributional feedback as well as instruction in arithmetic skills. Positive results were found in experiments using attributional feedback with regard to ability or effort. Schunk’s (1981; 1982) findings were validated by Relich (1984), who found that modeling and a treatment for ability attribution produced increases in performance and self-efficacy. In Relich’s study self-efficacy demonstrated a strong direct link to achievement.

Further evidence of the cogency of self-efficacy beliefs to academic pursuits can be observed in the meta-analysis by Multon, Brown, and Lent (1991). The researchers used 36 studies to investigate the relationship between self-efficacy and performance. The majority of
samples in the studies consisted of elementary school children (60.6%) and college students (28.9%) divided into students of normal achievement (55.3%) and low achievement (42.1%). The studies covered a variety of experimental designs and measures. Multon et al. found an overall effect size estimate for self-efficacy and performance of 0.38 representing 14 percent of the variance in students’ academic performance. It also was found that there was a stronger relationship between self-efficacy and performance for low achieving students (0.56 effect size) over normal achieving students (0.33 effect size). Age was also a factor. In the normal achievement range, high school and college students had greater effect sizes than elementary students, 0.41, 0.35, and 0.21 respectively. This may have been in part due to the more mature students being able to make more realistic judgments of their self-efficacy.

Self-efficacy has been shown to play an important role in academic performance. Under varied circumstances with varied experimental treatments, it has emerged as an important component in the process of motivating learners. Due to the increased importance that technology has placed on the quantitative skills necessary for many career options, a great deal of research has been performed in the area of cognitive skill development. Much of this research is performed in the context of mathematics learning. Self-efficacy for learning mathematics has been shown to be an important construct in the academic achievement of mathematics.

**Self-efficacy for mathematics**

A major goal listed by the National Council of Teachers of Mathematics is becoming confident in one’s mathematical ability (National Council of Teachers of Mathematics, 1989, p. 6). Research-based evidence validating this goal has accumulated over the years. However, the research in this area has suffered from a lack of specificity in terminology and measurement.
The three constructs most often cited in the literature relating to confidence in mathematics are *math self-concept, math self-efficacy*, and *math anxiety*.

In a meta-analysis by Schwarzer, Seipp and Schwarzer (1989), a negative correlation between mathematics anxiety and mathematics performance is observed. However, research has shown that, when self-efficacy is included in the analysis, it accounts for more variance in performance than does mathematics anxiety (Siegel, Galassi, & Ware, 1985). Other studies (Llabre & Suarez, 1985; Meece, Wigfield, & Eccles, 1990; Pajares & Kranzler, 1995) have shown that mathematics anxiety is not a good predictor of performance when variables such as self-efficacy, self-concept, experience, and perceived usefulness are used as controls. Thus, math anxiety is considered by many to be an artifact of poor perceptions of mathematics self-efficacy.

Self-concept refers to one’s aggregated self-perceptions that are (a) formed through experiences with and interpretations of the environment and (b) influenced by reinforcements and evaluations by significant other persons (Shavelson & Bolus, 1982). This construct is easily confused with self-efficacy, but there are distinct differences. Recall the definition of self-efficacy: “Perceived self-efficacy refers to beliefs in one’s capabilities to organize and execute the courses of action required to produce given attainments.” (Bandura, 1997, p. 3). In contrast to self-concept, self-efficacy is used in reference to some form of goal (attainment) and involves a situational context; “organize and execute courses of action required” (Bandura, p. 3). Self-concept is a global construct. Within the academic area students may have a high self-concept, but this feeling may not generalize to all academic areas or subjects. Bandura (1997) asserts that “A composite self-image may yield some weak correlations, but it is not equal to the task of predicting, with any degree of accuracy, the wide variations in behavior that typically occur in a
given domain of activity under different conditions” (p. 11). Research (Pajares & Kranzler, 1995; Pajares & Miller, 1994, 1997) supports this assertion. Use of the more domain specific math self-concept brings the self-concept notion closer to beliefs of math self-efficacy, but the differences detailed above still exist.

Self-efficacy in the context of learning mathematics has been studied for several years. Studies have been performed at all levels of the educational process and results have consistently shown that self-efficacy for mathematics has a positive relationship to mathematics performance. Results regarding math self-efficacy follow organized according to academic level: elementary school, high school, and college.

*Elementary school level mathematics*

In the 1980s Schunk and various colleagues conducted several studies involving elementary school students, mathematics achievement, and self-efficacy. These studies involved modeling, goal setting, and attributional treatments. Results of these studies show that self-efficacy for mathematics is an important element for mathematics achievement.

Schunk (1981) investigated the effects of modeling and attributional effects on children in the context of learning division skills. Subjects had an average age of 9 years, 10 months. Four treatments were used: cognitive modeling, didactic, attribution with modeling, and attribution didactic. The subjects in the cognitive modeling group observed an adult model solving division problems and received corrective modeling during a practice period. Subjects in the didactic treatment received the same instructional packets as the cognitive modeling group, but received no modeling. If students experienced difficulty with the practice problems, they were referred to the relevant pages of the instructional materials and were told to read the pages.
If there was further difficulty, the subjects were asked to read the relevant pages of the materials again. In the attribution with modeling and attribution didactic groups, the subjects were exposed respectively to the same conditions as the groups without attribution. In addition, the trainer for each group made comments attributing success to high effort and failure to low effort. All treatment groups were successful in developing division skills and increasing self-efficacy with the cognitive modeling group showing the greatest skill improvement. Multiple regression was used in the analysis and perceptions of self-efficacy accurately predicted performance on division skills across all treatments and levels of task difficulty. Subjects in a control group had no significant changes in self-efficacy and remained unskilled in division.

Bandura and Schunk (1981) investigated the effects of goal setting on subtraction skill, self-efficacy, and intrinsic interest in mathematics with a sample of elementary school children whose average age was 8.4 years. Subjects were randomly assigned to one of three treatment groups or a control group. All treatment groups used the same instructions, format, and materials, but differed in the goal setting. Treatment groups used proximal goals, distal goals, or no goals. The control group was administered all the assessment items as the treatment groups, but it was not exposed to any of the instructional materials. The proximal goal group showed the greatest increase in self-efficacy, performance in subtraction skills, and intrinsic interest. Perceived self-efficacy was positively related to subtraction accuracy and intrinsic interest in arithmetic activities.

Schunk continued his research on self-efficacy using subtraction skills and attributional feedback with elementary school children in a series of three studies (Schunk, 1982, 1983a, 1984). In each of those studies, a significant positive relationship was found between perceived self-efficacy for subtraction and achievement, thus strengthening the idea that perceptions of
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capability carry an important relationship to future achievement. Each of the three studies in this series confirmed prior research (Bandura & Schunk, 1981; Schunk, 1981) that self-efficacy judgments are not only reflections of past performance, but are formed by considering factors such as perceptions of ability, effort expended, task difficulty, situational circumstances, and patterns of failures and successes.

Schunk’s (1981) work on self-efficacy, attribution, and division was corroborated by Relich (1984). Relich investigated the effect of self-efficacy and attribution training on division skills. In this study a sample of children with an average age of 11 years and seven months was randomly assigned to a control group or one of four treatment groups: modeling, self-instructional practice, modeling with attribution, or self-instructional practice with attribution. The researcher used path analysis and found that “Self-efficacy displays a consistent and significant direct influence on division achievement” (Relich, p. 499).

Schunk’s (1981) earlier work on modeling and self-efficacy was validated by later studies by Schunk and Hanson (1985, 1989). These studies investigated the effect of peer modeling on self-efficacy, subtraction (Schunk & Hanson, 1985), and fraction skills (Schunk & Hanson, 1989). It was found that observing peer models led to greater increases in self-efficacy and subtraction skill than observing adult models or observing no model (Schunk & Hanson, 1985). Peer models that demonstrated coping-emotive behavior led to the highest self-efficacy for learning (Schunk & Hanson, 1989). In both studies self-efficacy and posttest performance were positively correlated.

Research spanning nearly a decade has uniformly shown a significant positive correlation between self-efficacy for mathematics and performance in elementary mathematics. That trend continues with high school students.
Research on self-efficacy and high school mathematics achievement has been performed using non-experimental designs. The research at this level of students’ education has focused on mathematics achievement and career choice. Self-efficacy has been shown, yet again, to be an important factor in both of these contexts.

Lopez and Lent (1992) investigated mathematics self-efficacy in an attempt to understand the sources of mathematics self-efficacy in high school students. Their goal with the study was to build on the literature in the area of career choice, and they believed that mathematics serves as an important filter in the career choice process. While not the main purpose of their study, the researchers found that math self-efficacy correlated significantly and positively with course grades. This study found evidence that high school students form their math self-efficacy beliefs largely from prior experiences and from emotional arousal information. Consequently, poor performance and lack of self-efficacy toward mathematics result in a lack of motivation to enroll in future math courses. Lopez and Lent suggest that high school educators and counselors should encourage students to consider the limiting effects of poor attitudes toward mathematics. Additionally, they suggest that remedial math programs should provide students with as many positive mastery experiences as possible and take steps toward reducing negative emotions toward mathematics.

Many studies of self-efficacy and math performance use standardized test scores or grades in prior courses as controls. Pajares and Kranzler (1995) had concerns about using such measures due to the difference in the math background of subjects, the attitude and anxiety factors associated with math tests, and the range restriction of college entrance exams such as the
ACT and SAT commonly used in research. The researchers decided to use a sample consisting of high school students rather than college students for their study. This decision was made with the intent to avoid the range restriction problems associated with assessing ability of college students. A measure of general mental ability was used to control for past performance in an attempt to avoid any anxiety issues that may have been realized using measures specific to mathematics. The main question of the researchers was whether or not self-efficacy would maintain a significant positive correlation with performance despite an expected strong correlation between mental ability and performance. As expected, the researchers’ path model found a significant direct effect of mental ability on math performance. The main question posed in this paper was answered when it was determined that self-efficacy was significantly, and nearly as strongly as mental ability, related to performance. In addition, self-efficacy was found to have a strong influence on anxiety, furthering the belief that math anxiety is a by-product of poor math self-efficacy. In their concluding remarks Pajares and Kranzler echo the recommendations of Lopez and Lent (1992) suggesting that since self-efficacy beliefs are such strong predictors of performance and math anxiety, educators should pay particular attention to students’ perceptions of competence as well as to actual competence.

Research revealing the significant influence of self-efficacy and mathematics achievement has continued to the present (Malpass, O'Neil, & Hocevar, 1999; Pietsch, Walker, & Chapman, 2003; Randhawa, Beamer, & Lundberg, 1993; Stevens, Olivarez, Lan, & Tallent-Runnels, 2004). Samples in these studies were drawn from Canada (Randhawa et al., 1993), Australia (Pietsch et al.), and the United States of America (Malpass et al.; Stevens et al.). The samples ranged in size from 144 (Malpass et al.) to 416 (Pietsch et al.). The samples consisted of subjects of varied ethnicity. Among others, Hispanic (Stevens et al.), Asian American
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(Malpass et al.), and Vietnamese (Pietsch et al.) students were represented. In each of these studies, math self-efficacy was positively related to math achievement. The sample used by Malpass et al. (1999) consisted of subjects who were enrolled in Advanced Placement mathematics courses. This fact separates the Malpass et al. study from most other studies involving high school students where subjects have been drawn from populations of low achievers or from more homogenous general student populations. At the middle school level a similar finding was made with gifted students (Pajares, 1996). Thus, self-efficacy has been shown to be an important component of mathematics achievement at varied levels of math aptitude.

At the high school level self-efficacy for learning mathematics has been shown to be a significant predictor of achievement in mathematics. Research findings indicate that regardless of ethnicity, cultural background, or math aptitude, self-efficacy for mathematics plays a vital role in the learning of mathematics for high school students. Many of these findings are echoed at the college level.

College level mathematics

Since Hacket and Betz (1981) proposed that Bandura’s (1977) self-efficacy theory could be extended to career development, the main focus of self-efficacy research at the college level has been in the context of career development. Research has shown that self-efficacy is an important predictor in the choice of college major, academic performance, and expressed interest in math courses (Betz & Hackett, 1981, 1983; Wheeler, 1983). This line of research was begun because of an interest in the lower enrollment of females than males in mathematics and technical majors. Significant differences in males and females regarding mathematics self-efficacy (Pajares & Miller, 1994) have been found, but this is not the norm. The bulk of the
Evidence accumulated in this line of research has shown no significant difference between males and females and mathematics self-efficacy (e.g. Hackett & Betz, 1989; Hackett, Betz, Casas, & Rocha-Singh, 1992; Lent, Brown, Gover, & Nijjer, 1996; Lent, Brown, & Larkin, 1986). This is somewhat surprising given the attention focused on the under-representation of females in math-related and technical fields. However, studies of mathematics self-efficacy typically do not use advanced concepts from mathematics, and gender differences in mathematics performance are increasingly seen only in more advanced mathematics (Feingold, 1988).

Lent, Brown, and Larkin (1986) used hierarchical regression analysis to study the relationship between self-efficacy, academic grades, retention, and perceived career options in science and engineering fields. Their assessment of self-efficacy was specific to engineering and science but included items such as ability to successfully complete the mathematics requirement for your engineering major so including their results in the current discussion is appropriate. Their analysis indicated that self-efficacy contributed significantly to the prediction of technical grades, persistence, and range of career options. The contribution of self-efficacy was significant even when variance due to math ability, high school achievement, and vocational interest were removed in previous steps of the regression procedure. Similar results were found by Hackett and Betz (1989). Hackett and Betz’s regression analysis revealed that when math self-efficacy, mathematics performance, and achievement variables were included, only math self-efficacy was a statistically significant contributor to the equation predicting choice of college major. Based on the findings of their study Hackett and Betz (1989) suggested that “mathematics teachers should pay as much attention to self-evaluations of competence as to actual performance” (p. 271). With the research supporting their findings, this appears to be a valid suggestion. If inaccurate perceptions of math self-efficacy could be identified early in a student’s academic
career, proper interventions could be undertaken that could have implications reaching far into that student’s academic career.

The studies of career development have found mathematics self-efficacy to play an important role in academic achievement as well. Lent, Brown, and Larkin (1986) found that self-efficacy for mathematics was a significant predictor of math achievement. The role of mathematics self-efficacy was independent of other factors they considered such as interest, math ability, and past achievement. Hacket and Betz (1989) arrived at similar conclusions. They found a positive correlation between math self-efficacy and math performance.

Outside of the interest in career development, researchers have found positive relationships between math self-efficacy and performance. Siegel, Galassi, and Ware (1985) found math self-efficacy to be superior to a model based on math aptitude and anxiety for predicting math achievement. In their study Siegel, Galassi, and Ware found a model consisting of math SAT score, math anxiety, sex, and sex role to be less predictive of variance in math exam scores than a model using math SAT, incentives, and math self-efficacy. Pajares and Miller (1994) hypothesized that math self-efficacy would have stronger direct effects on math problem-solving performance than math self-concept, math anxiety, prior experience, and gender. Their analysis supported their hypothesis. In fact, in their path-analysis the direct and total effects of math self-efficacy were significantly stronger than the effects of the other variables.

Volumes of research papers have found self-efficacy to be an important construct concerning academic achievement. Some research, however, has contradicted this evidence. As you will see in the next section, those contradictory studies are often flawed.
Research to the contrary

Not all researchers have found math self-efficacy to be predictive of performance. Benson (1989) found no relationship between math self-efficacy and performance, but did find a relationship between math self-concept and performance. However, in this study three global items were used to assess self-efficacy, and seven specific items were used to assess math self-concept. Thus, Benson used the two constructs differently than the majority of other researchers. Also, Benson used performance on a statistics mid-term exam as the performance measure. The subjects in this study were enrolled in one of three different statistics courses. Hence, the mid-term exams each covered different course material. Regardless of which course a subject was taking, the subjects all used the same instrument to report self-efficacy. This provides even more reason for the more global self-concept construct to be found as significant, and no relationship to be found with the more specific self-efficacy construct.

Like Benson (1989), Cooper and Robinson (1991) found that self-efficacy was not a significant predictor of math performance. But, like Benson, their assessments were also mismatched. Cooper and Robinson based math self-efficacy on the students’ confidence to succeed in ten advanced math courses. Once again, it appears as though math self-efficacy is being confused with math self-concept. Their self-efficacy measure was compared with scores on a performance instrument that consisted of solving math problems. As will be explained in more detail later, it is important that self-efficacy measures closely match the performance of interest in a given situation. Perhaps Cooper and Robinson (1991) and Benson (1989) would have had different findings, if their measures of math self-efficacy had been more closely matched with their performance measures.
Summary

Research findings support contentions that student motivation is better explained by self-efficacy than other cognitive or affective processes (Schunk, 1989; 1991). Collectively over two decades of research has demonstrated that students’ self-efficacy beliefs are valid predictors of student motivation and performance. These results have been found at various stages in the educational process and with a wide range of statistical controls. Specifically, higher self-efficacy for mathematics has been shown to be related to performance, persistence, reduced math anxiety, and greater interest in math related college majors and career choices. In many instances self-efficacy has been a better predictor of performance than prior experiences. Therefore, self-efficacy should be of concern to all educational practitioners.

Self-efficacy, academic self-efficacy, and math self-efficacy have been extensively researched over time. The same is not true of self-efficacy in online learning environments. This relatively new topic is the focus of the next section.

Self-efficacy in asynchronous online learning environments

Research on self-efficacy in online environments is in its infancy. Windschitl (1998) and Reinhart (1999) comment that most research on the topic of web-based instruction is in the form of case studies and descriptive accounts of specific design issues related to web-based instruction. Two years after Reinhart (1999) concluded that there was little research on web-based instruction, King (2001) found that self-efficacy research was lacking in the context of asynchronous distance learning. More recently, Miltiadou and Savenye (2003) came to the same conclusion, at least as far as research on motivation constructs in an online environment are concerned.
A possible explanation for the lack of research regarding motivation constructs such as self-efficacy in the online context is the lack of consideration the affective domain receives in the design process. Since affective behaviors are difficult to conceptualize and evaluate, they are often given little time in the design process (Martin & Briggs, 1986). Zvacek (1991) notes that when creating instruction for distance-education designers often focus on the questions: What do the students need to know? What instructional strategies will be most appropriate? On what criteria will the student be evaluated? Concern for the affective domain is obviously absent from this list. Many instructional designers are trained using the Dick and Carey (Dick & Carey, 1996) instructional design text. Dick and Carey note “many instructors consider the motivation level of learners the most important factor in successful instruction” (p. 92). Despite this comment one can see how the questions listed by Zvacek (1991) can overshadow motivation concerns, as the index of the Dick and Carey text lists only five pages on motivation.

In an attempt to obtain a broader view of the relationship between self-efficacy and online learning, self-efficacy for the use of computers in instructional situations will now be considered along with the limited research involving web-based instruction. Khan (1997) defines web-based instruction as “…a hypermedia-based instructional program which utilizes the attributes and resources of the World Wide Web to create meaningful learning environments where learning is fostered and supported” (p. 6). Computer assisted instruction is defined by Heinrich, Molenda, and Russell (1989) as “instruction delivered directly to learners by allowing them to interact with lessons programmed into the computer system” (p. 436). Both web-based instruction and computer-assisted instruction use computers to deliver instruction to learners and can allow learners to access material at their own pace or, otherwise, control the delivery of the instruction. Web-based instruction sometimes offers the learner access to more resources and
forms of communication than computer based instruction, but the similarities are sufficient to make results from computer-based instruction relevant to the current discussion.

Prior to the proliferation of the Internet, few studies were performed regarding self-efficacy and computers (Oliver & Shapiro, 1993). Most of the studies cited by Oliver and Shapiro are unpublished doctoral dissertations, which emphasizes the dearth of research on the subject at the time of their review of the literature. The research on self-efficacy and computers is primarily related to people’s confidence to use technology.

It has been shown that perceived efficacy for using computers leads to a higher likelihood of using them (Ertmer, Evenbeck, Cennamo, & Lehman, 1994; T. Hill, Smith, & Mann, 1987; Jorde-Bloom, 1988). In the studies by Hill, Smith, and Man and Ertmer, Evenbeck, Cennamo, and Lehman, it was determined that the quality of the experience (i.e. positive experience), not simply any prior experience, increased self-efficacy for computers and thus influenced future usage. Several studies have shown that anxiety toward computer use is a major obstacle in educators’ adoption of computers (e.g. Hakkinen, 1995; McInerney, McInerney, & Sinclair, 1994; Reed & Overbaugh, 1993; Stimmel, Connor, McCaskill, & Durrett, 1981).

Other computer self-efficacy studies have been performed using information technology or information systems courses at the undergraduate level (Karsten & Roth, 1998a, 1998b; Langford & Reeves, 1998). Collectively, these studies found that higher levels of computer self-efficacy correlate with increased performance in computer courses and increased achievement of computer competency. Additional recent studies of self-efficacy and online learning have had various findings. Lim (2001) found that self-efficacy is an accurate predictor of learners’ satisfaction with web-based courses. Holcomb, King, and Brown (2004) found no gender differences for self-efficacy beliefs regarding the use of technology.
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In a paper relating self-efficacy to the rapidly evolving Internet, Bandura (2002) deduces that the information technology tools available to learners in online courses are useful only if learners possess self-efficacy for regulating their own learning, which he proposes will result in positive self-efficacy to use the Internet. Bandura goes on to claim it is those learners who will make the best use of internet-based instruction. However, research on self-efficacy and self-regulated learning in online environments is inconclusive. King (2001) found that there was no significant difference in the achievement of groups of students with high or low self-regulatory skills. Joo, Bong, and Choi (2000) found that self-regulatory self-efficacy did not directly predict students’ performance outcomes. Through its links to more specific self-efficacy variables, they determined that self-efficacy for self-regulation was related indirectly to final performances.

Bandura’s (2002) claim that increased self-efficacy to use the Internet will result in the best use of Internet-based instruction is not clear either. In a study of 73 community college students enrolled in web-based distance education courses, DeTure (2004) found that self-efficacy with online technologies was a poor predictor of student success. A similar result was found earlier by Lee and Witta (2001) using a sample of 16 college students. Lee and Witta found that measures of self-efficacy for online technologies were not significant predictors of performance in the class, but, when measured near the end of the semester-long study, they were significant predictors of performance. Curiously, however, the relationship between self-efficacy for online technologies and performance in the course was negative. Lee and Witta hypothesized that students who were comfortable with the online technologies may have expended less effort on the class in contrast to students who were not comfortable with the technologies. Wang and Newlin (2002) studied self-efficacy for online technologies using a
sample of 122 students enrolled in a web-based research methods in psychology course. In this study, the researchers found self-efficacy for online-technologies to be a good predictor of student performance in the course.

The studies of DeTure (2004), Lee and Witta (2001), and Wang and Newlin (2002) contain several issues worthy of criticism. DeTure’s sample consisted only of students that self-selected into the online courses. If the students chose to enroll in an online class, perhaps their self-efficacy toward technology was at a high level. Evidence of this ceiling effect can be observed as DeTure reports that the statistical mode for the measure of online technology self-efficacy was also the maximum score for this measure, and the standard deviation was relatively small. Hence, the self-efficacy for online technologies data collected from this sample may not have been variable enough to be useful in the regression analysis. The generalizability of Lee and Witta’s study is in question due to the small sample used (only 16 students) and it is unclear whether or not the students self-selected into the online course. Wang and Newlin also used only students that self-selected into the course for their study. While self-selection into courses is typical, it is of concern when considering self-efficacy as the students may have high efficacy beliefs regarding success in the course.

Research on the relationship between self-efficacy for course content and performance in online courses is mixed. Lee and Witta (2001) found that self-efficacy for course content was not a predictor of performance in the online course they studied. Evidence contradicting this was found by Wang and Newlin (2002) who determined that self-efficacy for course content was correlated to scores on the cumulative final exam used in their study. Joo, Bong, and Choi (2000) found that academic self-efficacy was not predictive of performance on a web-based test, but was predictive of performance on a written test.
Summary

Research on self-efficacy in asynchronous online learning environments is new and inconsistent. There is consensus in the research that self-efficacy beliefs regarding the use of computers is related to future use of computers and a reduction in anxiety for using computers. But, a clear link between self-efficacy for computers and performance in online courses in general has yet to be established. Self-efficacy for course content, academic self-efficacy, has consistently been shown to be significantly related to outcome measures such as grades and exam scores in traditional classroom situations. Such relationships have yet to be established for online courses. Perhaps as robust measurement instruments are developed, and more research in this area is conducted, self-efficacy in online environments will be understood more fully.

The background on self-efficacy and its relationship to academic endeavors has now been established. The body of literature on the topic consistently shows that self-efficacy is an important element of students’ beliefs regarding academics. But, how does one develop self-efficacy beliefs? Developing self-efficacy beliefs is the focus of the following section.

Developing Self-Efficacy

Sources of Self-efficacy

Bandura’s (1977) introduction of self-efficacy theory included the proposition that self-efficacy is derived from four principal sources: performance accomplishments, vicarious experience, verbal persuasion, and physiological and affective states. Bandura’s work is consistent in this proposition (Bandura, 1981, 1997), though performance accomplishments are now commonly referred to in the literature as enactive mastery experiences. These four areas are accepted as the core elements in the development of self-efficacy, though recently Schunk and
Pajares (2002) have suggested familial, peer, school, and transitional influences as important sources in the development of academic self-efficacy.

*Enactive mastery experiences.* Enactive mastery experiences refer to previous, successful experiences a learner has had performing a task. Successes build positive self-efficacy beliefs. Failures undermine self-efficacy, especially if failures are experienced before a firm belief in one’s self-efficacy is formed. Bandura (1997) writes “Enactive mastery experiences are the most influential source of efficacy information because they provide the most authentic evidence of whether one can muster whatever it takes to succeed.” (p. 80). Bandura (1997) cites several studies which demonstrate the power of enactive mastery experiences. Research in the development of mathematics self-efficacy has substantiated this claim as well (Lent, Brown et al., 1996; Lent, Lopez, & Bieschke, 1991; Lent, Lopez, Brown, & Gore, 1996; Lopez & Lent, 1992).

Self-efficacy, however, is not simply a reflection of prior performance. Self-efficacy beliefs are formed by a cognitive process that weights several factors in the determination of self-efficacy beliefs. Task difficulty and the context in which the prior performances were accomplished are each evaluated in the cognitive process of forming self-efficacy beliefs. Tasks perceived as simple will not aid in the development of increased self-efficacy. Likewise, tasks perceived as extremely difficult will not increase self-efficacy beliefs due to the uncertainty of being able to achieve success on a future attempt. Research has shown that successful completion of a task requiring enormous effort can actually reduce self-efficacy (Bandura & Cervone, 1986). In a similar manner, if the context of a successful performance is such that a great deal of external assistance is received, or the circumstances under which one performs are perceived as unusual, self-efficacy may not be increased.
Vicarious Experience. Vicarious experience refers to one’s observation of a role model performing a task successfully. This type of social comparison is particularly valuable in the formation of self-efficacy beliefs. In many situations one cannot determine whether or not a performance should be deemed a success or failure until there is some knowledge of how others have performed at a similar task or equivalent. Transcending the performances of others increases self-efficacy and failing to meet the performances of others lowers self-efficacy. The formation of self-efficacy beliefs will vary depending on the abilities of those chosen for comparison (Wood, 1989). Hence, care should be used when selecting models for comparison.

Studies involving mathematics self-efficacy have shown modeling to be a valid method of increasing self-efficacy. Studies have demonstrated this validity at the elementary school level (Schunk, 1981; Schunk & Hanson, 1985), the high school level (Lent, Lopez et al., 1996), and the college level (Lent, Lopez et al., 1996; Matsui, Matsui, & Ohnishi, 1990). The use of peer models versus adult models appears to be most important in k-12 learners, with adult models demonstrating no difference from peer models at the college level. Lent, Lopez, Brown, and Gore (1996) note that vicarious experiences are supportive of mastery experiences in mathematics, but do not ensure them.

Vicarious experiences are easy to imagine in the context of physical performances. The utility of vicarious experiences in the learning of cognitive skills, such as math problem solving bears mentioning. In conveying cognitive skills, models should verbalize their thought processes. When cognitive skills are modeled, the competence of the model and whether or not the model will display coping strategies or mastery are important factors to consider. Vicarious learning has been used successfully in the context of learning mathematics by the use of verbalizing the thought process (Schunk, 1981; Schunk & Hanson, 1985).
Verbal persuasion. Verbal persuasion is commonly used due to the ease with which it can be dispensed. Verbal persuasion has limitations, but can be useful when used in conjunction with opportunities for performance practice (Bandura, 1977). The credibility and competence of the persuaders plays an important role in the use of verbal persuasion. The receiver must view the persuader as someone who is qualified to provide meaningful and accurate feedback. Persuasive comments are of greatest benefit when the task at hand is perceived to be just beyond the capabilities of the receiver. Bandura (1997) cautions that verbal persuasion consists of more than flippant, off-hand comments of encouragement. Unrealistic persuasory feedback may mislead the receiver resulting in failure, which in turn may decrease self-efficacy and diminish the belief in the persuader as a credible judge of the performance. “Skilled efficacy builders encourage people to measure their successes in terms of self-improvement rather than in terms of triumphs over others.” (Bandura, 1997, p. 106).

Mixed results have been found with verbal persuasion and math self-efficacy. It has been found to be an insignificant or nonexistent contributor to math self-efficacy (Lent, Brown et al., 1996; Matsui et al., 1990) and a significant source of math self-efficacy (Lent, Lopez et al., 1996). This confusion is hypothesized to stem from the fact that the four primary sources of self-efficacy are highly interrelated (Lent et al., 1991; Lent, Lopez et al., 1996; Matsui et al., 1990). Persuasory information in the form of evaluative feedback, however, has shown consistent results in experimental research. When students have been provided with either ability or effort feedback during mathematics practice, self-efficacy and mathematics achievement have increased (Relich, 1984; Schunk, 1981, 1982, 1983a, 1984; Schunk & Hanson, 1989).

Physiological and Affective States. People rely on physiological and emotional feedback when forming their self-efficacy beliefs. Stress, emotion, mood, pain, and fatigue are interpreted
when making judgments of one’s physiological and affective states. In general, success is expected when one is not in a state of aversive arousal (Bandura, 1997). However, the level of arousal is just as important as the arousal itself. High arousal can weaken performance. Modest levels of arousal can increase attention and facilitate the use of skills. The most desirable level of arousal is a function of the complexity of the task at hand. Simple tasks and tasks that have become involuntary are not easily influenced by physiological or affective arousal, but complex activities requiring organization and precision are vulnerable to disruption by such arousal (Bandura, 1997).

Researchers have found emotional arousal to be correlated with self-efficacy beliefs toward mathematics (Lent et al., 1991; Lent et al., 1996; Lopez & Lent, 1992; Matsui et al., 1990). However, the effect is small or nonexistent when other sources of math self-efficacy are considered (Lent et al., 1991; Matsui et al., 1990). As in the case of verbal persuasion, the interrelatedness of the four primary sources of efficacy information seems to confound the determination of the contribution made by physiological and affective states.

**Familial, Peer, and School Influences.** Schunk and Pajares (2002) highlight familial, peer, schooling, and transitional influences in the development of academic self-efficacy. The familial and peer influences as explained by Schunk and Pajares are combinations of Bandura’s (1977) four primary sources of self-efficacy.

Parents who provide home environments that are stimulating, encouraging, and allow for mastery experiences, assist children in the development of positive self-efficacy beliefs regarding learning. Parents and siblings also serve as models of behavior and as sources of verbal persuasion. Peers provide salient models through which vicarious learning occurs. Schunk and Pajares (2002) cite several studies affirming the important role of peers and peer groups in the
formation of efficacy beliefs in children. Specifically, Schunk and Pajares cite findings of Steinberg, Brown, and Dornbusch (1996) in which high school students who affiliated with academically oriented peer groups achieved better than students affiliated with less academically oriented groups.

Self-efficacy beliefs tend to decline as students progress through school (Pintrich & Schunk, 1996). This decrease is attributed to factors such as increased competition, ability groupings, less teacher attention to individuals, norm-referenced grading, and stress. The change in these factors as students progress through elementary, middle, and high school is what Schunk and Pajares (2002) term transitional influences. These factors make achievement more difficult. There is a decrease in positive persuasion from teachers. Norm-referenced grading makes finding peers who are above average a difficult task. Hence, the positive impact of enactive mastery, vicarious learning, and verbal persuasion lessens.

Developing Self-Efficacy Online and at a Distance

The obvious isolation of online and distant learners makes addressing the four principal sources of self-efficacy development a challenge. Most research on self-efficacy in online or distance environments involves measures of self-efficacy, but treatments to increase self-efficacy in these environments are seldom found in the literature.

Jackson (2002) used e-mail with a traditional face-to-face class in an attempt to enhance self-efficacy. Students in Jackson’s treatment group received an email that emphasized past successes of the student, related the fact that similar students had been successful in the course before, encouraged the student to work hard and stay focused, and provided stress-reduction tips.
Jackson found that self-efficacy was significantly related to performance and that self-efficacy was enhanced by the e-mail communication.

Visser, Plomp, Amirault, and Kuiper (2002) used what they called a *motivational message* to address course completion rates in an online course. In their research they used traditional postal services for their messages because the subjects in their study were located in countries lacking in the technology necessary to use electronic means. Visser et al. found confidence to be the most frequent learner concern. At the conclusion of their study, Visser et al. found that their motivational messages were effective in increasing retention in the course. They also found that their messages had a strong positive impact on the level of self-confidence of the learners.

The interventions of Jackson (2002) and Visser et al. (2002) both involved written communication and seem to fall best in Bandura’s (1977) verbal persuasion category. The studies of Jackson (2002) and Visser et al. (2002) are the most overt examples of research on self-efficacy online or at a distance. Other treatments in online and distance learning may indeed affect learning through self-efficacy via the use of models in video (vicarious learning), audio communication, or social comparison information, but my extensive search of the self-efficacy literature has not produced such studies with self-efficacy as a variable of interest.

**Summary**

Research suggests that the four sources of self-efficacy proposed by Bandura (1977) are indeed the primary sources of math self-efficacy. Enactive mastery experiences appear to the strongest influence on students’ perceptions of math self-efficacy. However, the other factors are not to be ignored as they can provide important information for the formation of math self-
efficacy as well. Using instructional materials designed to provide students the opportunity to be successful and achieve mastery can enhance self-efficacy. Coupling such materials with modeling and verbal persuasion strengthens self-efficacy even further. It seems to follow that experiences designed using these strategies will reduce negative emotions regarding mathematics, thus, reducing the negative impact that adverse emotional states can have on math self-efficacy beliefs.

In online and distance learning environments self-efficacy research is typically non-experimental. Few research studies manipulating self-efficacy variables in distance or online learning exist. The few such studies that do exist indicate that self-efficacy can be developed through the use of the written word and that increased self-efficacy has positive effects on learning in those environments. In online and distance learning environments, like all learning environments, materials and activities should be designed to provide students with the opportunity to build skills through multiple mastery experiences. The successful experiences of learners in these environments would assist in the development of positive self-efficacy beliefs, thus, leading to increased academic performance in future endeavors.

The sources of self-efficacy have been delineated and some strategies to increase self-efficacy have been described. How does one determine whether or not self-efficacy has been increased? This question is investigated in the next section on the assessment of self-efficacy.

Assessment of Self-efficacy

Self-efficacy by definition “refers to beliefs in one’s capabilities to organize and execute the courses of action required to produce given attainments” (Bandura, 1997, p. 3). Self-efficacy measures are typically presented as surveys on which respondents judge their capabilities to
successfully perform given tasks. Note that in agreement with the definition the respondents are not asked to actually perform the task. Also, note that the judgment is not made with regard to the performance of others. The respondents are asked to judge their capability to perform the task successfully -- to master the task. Self-efficacy beliefs are domain and context specific. A measure of mathematics self-efficacy would be inappropriate if one were attempting to obtain information regarding self-efficacy for history. Likewise, the context plays an important role in the judgments. Performing a complex learning task under adverse conditions such as in a noisy environment is quite different from performing the same task under optimal learning conditions.

Bandura (1997; 2001a) provides several guidelines to be used in the construction of self-efficacy scales. His first suggestion is that one considers the level, generality, and strength of the beliefs to be measured. Level refers to the variations in one’s efficacy beliefs related to the demands of the task under consideration. When constructing efficacy scales, Bandura suggests researchers draw on expert knowledge, interviews, and open-ended surveys to determine the levels of challenge in the task to be performed (Bandura, 1997). Generality refers to the range of activities or domains over which people consider themselves efficacious. “Generality can vary across types of activities, the modalities in which capabilities are expressed (behavioral, cognitive, affective), situational variations, and the types of individuals toward whom the behavior is directed.” (Bandura, 2001a, p. 5) Strength refers to the level of tenacity a person will exhibit to produce an attainment. People with strong efficacy beliefs for a particular task will persevere under extreme difficulty, while people with weak efficacy beliefs are easily discouraged. Bandura (1997) suggests that measures of efficacy beliefs present respondents with items that describe different levels of task demands. Research indicates that items should be presented in random order or ascending order with respect to task difficulty to avoid artificially
Self-efficacy judgments (Berry, West, & Dennehey, 1989). Bandura (1997) also suggests that respondents rate their belief in their ability to successfully perform the tasks on a scale ranging from 0 to 100 in steps of ten. A response of 0 indicates ‘cannot do’ and a response of 100 indicates ‘certain can do’.

A frequent topic of discussion regarding assessment of self-efficacy beliefs is the level of specificity of the instrument. Precise judgments of capability paired with specific outcomes yield the best predictions and offer the best explanations of performance outcomes (Bandura, 1986). Research has confirmed this assertion. In their meta-analysis of self-efficacy beliefs, Multon, Brown, and Lent (1991) found that the strongest effects were found by researchers who used specific measures of self-efficacy paired with corresponding performance measures.

Some criticisms of strictly specific self-efficacy instruments are that micro levels of specificity reduce external validity and practical relevance (Lent & Hackett, 1987), and that self-efficacy research will be so costly, time consuming, and unattractive as to not be pursued (Nielsen & Moore, 2003). Research on general academic self-efficacy has found that as students gain expertise in academic domains, they become more context specific in their self-efficacy judgments (Bong, 1999). Additionally, Bong (1997) found that students’ self-efficacy perceptions transcend the boundaries of specific problems to more domain specific beliefs (i.e. mathematics self-efficacy instead of addition self-efficacy) and to a lesser degree the boundaries between academic subjects. That is, students’ self-efficacy judgments were comparable when there was a perceived similarity between tasks such as mathematics and physics. These findings do not contradict Bandura’s (1986) suggestions, but do support his suggestion that the level of generality of the efficacy measure match the level of generality of the performance measure.

The mismatch of self-efficacy and performance measures produces results that are to be
read with skepticism. This research error was discussed earlier in the context of mathematics self-efficacy in the studies of Benson (1989) and Cooper & Robinson (1991). A third example of this error is provided in Smith, Arnkoff, and Wright (1990). The researchers in this study found self-efficacy to be a weak, but significant, predictor of performance. Their findings may have been much different had their self-efficacy measures matched their performance measure. Self-efficacy was measured in relation to study skills. The performance measures were course grades. Had the researchers in this study used an appropriately matched pair of self-efficacy and performance measures, their findings may have been much different.

A successful implementation of a general self-efficacy measure and an appropriate performance measure is seen in Pajares and Miller (1995). In this study, three types of mathematics self-efficacy were assessed: confidence to solve math problems, confidence to succeed in math-related courses, and confidence to perform math-related tasks. Data were collected on solution of math problems and choice of math-related major. As theorized, confidence to solve math problems was a more powerful predictor of the math problem solving performance. Furthermore, confidence to succeed in math-related courses was the best predictor of choice of math-related major.

In sum, measures of self-efficacy should be constructed with careful attention given to the performance measure with which they will be compared. The self-efficacy and performance measures should be comparable in specificity. Researchers should perform careful task analysis so that varied levels of performance can be represented in their measures. Items on the measures should be arranged in random or ascending order of difficulty. Finally, to increase the level of discrimination of self-efficacy beliefs, measures should be constructed with 0-100 response types rather than smaller numbers of response choices. Measures relevant to mathematics self-efficacy
Assessing Mathematics Self-Efficacy

A review of the studies involving mathematics self-efficacy considered for this work yields no common instrument to assess mathematics self-efficacy. By and large researchers construct their own ad hoc measures of self-efficacy. This finding is not surprising given the theoretical guidelines for self-efficacy scales, which suggest that for greatest predictive value, the self-efficacy measure should be specific to the situation at hand. While still not a commonly used instrument, the Mathematics Self-Efficacy Scale (MSES) has received some attention in the literature. Betz and Hackett (1983) developed the MSES to study the mathematics self-efficacy of college students. The MSES is a 52-item scale consisting of three sub-scales: solution of math problems, completion of math tasks used in everyday life, and satisfactory performance in college mathematics courses. Betz and Hacket borrowed their \textit{solution of math problems} subscale from Dowling (1978). Since its development, the MSES has been used in studies of academic performance and career choice. It has been shown to be a strong predictor of college major choice (Hackett, 1985; Hackett & Betz, 1989) and a moderate predictor of math problem solving (Hackett & Betz, 1989). Pajares and Miller (1995) modified the MSES creating the MSES Revised (MSES-R). They replaced the \textit{solution of math problems} subscale used by Betz and Hacket with a final version developed by Dowling (1978). Pajares and Miller also reduced the 10-point Likert scale to a 5-point scale. They also replaced one question regarding the use of a slide rule with a similar question regarding the use of a calculator. Kranzler and Pajares (1997) found the MSES-R to have high internal consistency. Cronbach’s alpha values of .94, .91, .91, .95 were reported for the subscales: completion of math tasks used in everyday life, satisfactory performance in college mathematics courses, solution of math problems, and the entire scale.
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respectively. Kranzler and Pajares caution that though the MSES-R is a reliable instrument, researchers should heed guidelines of matching self-efficacy measurements and performance measures as closely as possible. They also suggest broad measures of self-efficacy like the MSES-R may be of most use to broad interests such as college major choice and intention to take math-related courses. The high internal consistencies of the MSES-R observed by Kranzler and Pajares also validate using a smaller number of Likert response items than suggested by Bandura (1997).

Assessing Self-Efficacy for Online Learning

Research related to self-efficacy and learning online is in its infancy. Computers are an important component of online learning, hence, measures of self-efficacy toward computers are relevant to the present discussion. As mentioned earlier in this work, self-efficacy for computers is most often assessed in the context of computer use or computer adoption. As Bandura (1997; 2001a) suggests in general, Delcourt and Kinzie (1993) recommend that self-efficacy be measured for specific technologies needed in the use of computers rather than as a global measure of computer self-efficacy. Heeding this advice many researchers create their own measures of computer self-efficacy or adapt existing measures to suit their particular situation. Three measures of computer self-efficacy have emerged in my review of the literature as the most often used or adapted measures: Murphy, Coover, and Owen’s (1989) Computer Self-Efficacy Scale (CSE), Delcourt and Kinzie’s (1993) Self-Efficacy for Computer Technologies (SCT) scale, and Compeau and Higgins’ (1995) measure. Recently, a measure aimed specifically at self-efficacy for online technologies, the Online Technologies Self-Efficacy Scale
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(OTSES), has been developed (Miltiadou & Yu, 2000). All of these instruments will now be discussed.

**Computer Self-Efficacy Scale (CSE).** The CSE (Murphy et al., 1989) was developed to measure self-efficacy beliefs toward the skills necessary for graduate students and practicing professionals to use micro- and mainframe computers. Murphy et al. developed the items for the CSE by reviewing the literature, examining courses teaching computer skills, and using expert reviewers. The CSE consists of 32 items comprising three subscales: beginning level computer skills, advanced level computer skills, and mainframe computer skills. Respondents are asked to rate their confidence for each item using a 5-point response format ranging from (1) very little confidence to (5) quite a lot of confidence. A review of the CES demonstrates that the beginning and advanced level computer subscales are still relevant today, thus, explaining its continued use. The mainframe subscale is relevant to very few individuals due to advances in computer technology. In addition to content validity, Murphy et al. (1989) report high alpha reliability levels for the subscales: beginning level computer skills, .97; advanced level computer skills, .96; and mainframe computer skills, .92.

**Self-Efficacy for Computer Technologies (SCT) Scale.** The SCT (Delcourt & Kinzie, 1993) was developed specifically for the population of teachers and teacher education students. The tasks used in their scale, however, would be applicable to many situations. Delcourt and Kinzie followed the same development process as Murphy, Coover, and Owen (1989) and cite them as one of their principal sources. The SCT consists of 25 items across three subscales: word processing, electronic mail, and CD-ROM databases. Respondents rate each item with a 4-point Likert scale ranging from (1) strongly disagree to (4) strongly agree. All three subscales were found to have high alpha reliability levels: .97 for word processing and .98 for both the
electronic mail and CD-ROM database subscales (Delcourt & Kinzie, 1993). Similarly high alpha reliability levels were found by Ertmer, Evenbeck, Cennamo, and Lehman (1994) and Albion (2001) for modified versions of the SCT. The word processing and electronic mail subscales are still relevant today, but since technology has mostly left CD-ROM databases behind by moving these resources to the Internet, that subscale is of limited value now.

Joo, Bong, and Choi (2000) used modified versions of the CSE (Murphy et al., 1989) and the version of the SCT used by Ertmer, Evenbeck, Cennamo, and Lehman (1994) along with five newly developed items specific to web-based instruction to measure Internet self-efficacy. Their 13-item scale demonstrated an alpha reliability level of .95. Joo, Bong, and Choi (2000) did find that their measure of Internet self-efficacy was predictive of success on an Internet search task.

**Compeau and Higgins.** Compeau and Higgins (1995) developed a 10-item measure of computer self-efficacy focused on a respondent’s perception of ability to accomplish a job task with a computer. On this measure respondents rate their confidence to perform a job task using a 10-point scale ranging from (1) not at all confident to (10) totally confident. Contrary to most self-efficacy research the Campeau and Higgins (1995) instrument is completely non-specific. Respondents are given a vague hypothetical job situation in which an unknown and hypothetical software package will be used. This type of non-specific, hypothetical situation seems to not be in agreement with the requirements of a self-efficacy measure. “Self-efficacy refers to beliefs in one’s capabilities to organize and execute the courses of action required to produce given attainments” (Bandura, 1997, p. 3). Despite being cited often in the literature as a measure of computer self-efficacy, I question the construct that this scale is indeed measuring because of the type of question it presents to the respondent. The items in the Campeau and Higgins scale are
not asking the basic self-efficacy question of “Can you do it?”, but are asking questions such as “Can you do it, if someone helped you?”.

*Online Technologies Self-Efficacy Scale (OTSES).* Miltiadou and Yu (2000) have developed a 29-item scale to measure students’ self-efficacy perceptions regarding online communication technologies. They found the OTSES to have an alpha reliability coefficient of .95. Factor analysis revealed only one scale is measured with this instrument, which they call *online self-efficacy.* Several technologies are represented in their scale: web browsing, email, synchronous and asynchronous chatting. Students rate their confidence for various specific tasks using a 4-point scale ranging from “very confident” to “not confident at all”. After reviewing the CSE of Murphy, Coover, and Owen (1989) and the SCT of Delcourt and Kinzie (1993), one should notice that the OTSES appears to be a blend of these two earlier scales updated for currently available Internet technologies.

**Summary**

Self-efficacy scales should closely match the performance measures with which they are paired when such comparisons are to be made. In the construction of scales, researchers must perform careful analysis of the tasks for which self-efficacy is being measured so that various levels of attainment can be measured. In many instances researchers follow these guidelines, and thus, there are few self-efficacy scales prominent in the literature. Scales specific to computer use have been created that have proven to be reliable and, with some modifications, relevant over time.

The research literature on self-efficacy is strongly linked with the literature on self-regulation. Self-efficacy involves the confidence a learner has to succeed and self-regulation
involves the processes necessary for learners to sustain learning activities needed to achieve success. Thus, the link between the constructs is logical and should be of interest to those who wish to create effective leaning environments. A brief review of academic self-regulation follows.

Self-regulation

Self-regulation refers to the degree to which learners are “metacognitively, motivationally, and behaviorally active participants in their own learning process” (Zimmerman, 1989, p. 329). The interdependent relationship between self-regulation and self-efficacy with respect to academics can be seen in the literature. Research has found that students with higher levels of self-efficacy are more likely to demonstrate self-regulated learning (Tuckman & Sexton, 1991; Zimmerman & Martinez-Pons, 1990). Conversely, self-efficacy for self-regulated learning has been found to affect academic self-efficacy (Zimmerman et al., 1992). This two-way relationship is further illustrated by Pintrich and De Groot (1990), who found that cognitive and self-regulation strategies were more important than self-efficacy beliefs for academic performance, but that increased self-efficacy beliefs may result in more use of cognitive and self-regulatory strategies.

Staying within the social cognitive view used throughout this review, self-regulation can be described using a triadic reciprocality. In such a reciprocal there are three basic, interdependent elements of the construct. In the case of self-regulation, those three elements can be described as behavior, environment, and self (Zimmerman, 1989). Like the relationships for self-efficacy, the reader should not assume that the three components of this reciprocality are weighted equally. At any given time, one or more of the components may be the predominant
factor (Bandura, 1986). The three components of this reciprocality will now be examined in more detail.

*Behavioral components of self-regulation*

Bandura (1986) proposed three internal subfunctions involved in one’s self-regulation that result from one’s interaction with the environment: self-observation, self-judgment, and self-reaction. The same year as Bandura’s proposal, McCoombs (1986) suggested a similar framework of self-awareness, self-monitoring, and self-evaluation. The outcomes of McComb’s processes are perceptions, judgments, and expectations respectively. Whereas Bandura’s terminology is most prominent in the literature, it will be used in this discussion. Self-observation serves the learner by providing the information necessary for setting reasonable goals. Self-observation is limited by certain factors. Bandura (1986) cautions that behaviors are most likely to be affected by self-observation when the time of the observation is in close proximity to the behavior and when there is noticeable progress. The positive effects of self-observation on self-regulation can be seen in the literature. Schunk (1983b) and Lan (1996) found that self-monitoring improved persistence and increased the use of self-regulated learning strategies, as well as increased skill and knowledge. Self-observation is indeed important, but without an evaluation of the observation, that information is of little help to the learner.

Zimmerman (1989, p. 333-334) states that “self-judgment refers to students’ responses that involve systematically comparing their performance with a standard or goal.” Personal standards, valuation of the activity, and attributions are key elements of the self-judgment process (Bandura, 1986). Personal standards are developed mostly through social comparison. Valuation of the activity refers to the fact that people value activities that are relevant to them.
Finally, attributions refer to whether or not success or failure is perceived to be due to ability or effort, or whether an outcome is the result of an external, uncontrollable force.

The processes of self-observation and self-judgment combined allow for the possibility of self-reaction. Bandura (1986) posits that self-observation and self-judgment lead to one of three possibilities: evaluative self-reactions, tangible self-reactions, or no self-reaction. Judging one’s actions may lead to feelings of satisfaction or dissatisfaction. Internal standards may be modified. Tangible rewards (e.g. relaxation, recreation) are sometimes used to motivate performance.

Numerous studies have been conducted in which children and adults regulate their own behavior by arranging tangible incentives for themselves. The results show that people who reward their own attainments usually accomplish more than those who perform the same activities under instruction but without rewarding their attainments.

(Bandura, 1986, p. 351)

There is an obvious interdependent nature of the Bandura’s three behavioral components of self-regulation. This interdependence is described by Zimmerman and Schunk (1989) as an *enactive feedback loop*. This terminology captures the essence of the interdependence well.

*Environmental components of self-regulation*

Learners can obtain much from their learning environments. Exposure to peer models, verbal persuasion, and assistance from peers or teachers are some ways that learners may benefit from their environments. A learner’s environment provides information regarding self-
Self-efficacy, Motivational Email, and Achievement

regulation mainly through enactive outcomes and vicarious experience (Bandura, 1986). Schunk and Hanson (1985, 1989) found that the observation of models who verbalized their methods of solving problems led to increased self-efficacy and achievement in their arithmetic tasks. In addition to models, verbal persuasion has been found to be valuable in the development of self-efficacy and academic achievement (Relich, 1984; Schunk, 1981, 1982, 1983a, 1984; Schunk & Hanson, 1989). These are explicit examples of how the environment affects self-efficacy, but due to the interdependent nature of the environment, self, and behavioral aspects of self-regulation, these environmental factors then affect self-regulation.

One does not only receive information from the environment, but a sense of control over the environment also has been shown to be important with regard to self-regulation. Bandura and Wood (1989) conducted an experiment in which participants were managing a simulated organization. Participants who managed under the assumption that the organization was controllable exhibited a strong sense of self-efficacy and set challenging goals. Participants who did not believe the organization was controllable, displayed low self-efficacy and set low goals. Zimmerman and Martinez-Pons (1986, 1988) found that self-regulation included social and environmental aspects. The social component was displayed by learners seeking assistance from others in their environment such as teachers and peers. Creating special study areas or arranging for access to resources by working in a library are examples of the environmental component.

**Personal components of self-regulation**

Zimmerman (1989) identified self-efficacy as the most important construct related to one’s personal components of self-regulation. Given the extensive treatment of self-efficacy earlier in this discussion, only the connection between self-efficacy and self-regulation will be
discussed here. Goal intentions are the mediating concept between self-efficacy beliefs and self-regulation. The importance of goals for self-regulation is seen in Driscoll (2000), who states, “self-regulation becomes possible when learners acquire the metacognitive skills to monitor their progress toward goal attainment and sustain their own motivation during learning.” (p. 317-318). Bandura (1977) identified goals as an important element of motivation in his seminal work on self-efficacy. Goals may be examined using several characteristics. Proximity, specificity, source, and orientation are the most common characteristics of goals associated with learning.

The proximity of a goal refers to the perceived discrepancy between the current performance and the goal performance. Proximity may refer to an actual time such as a short-term goal versus a long-term goal, or to a level of performance such as a slight improvement or a major improvement in performance. In general, proximal goals are better motivators than distal goals. This could be because decisions in the self-judgment process are easier to make. Bandura and Schunk (1981) found that with the use of proximal goals learners “progressed rapidly in self-directed learning, achieved substantial mastery of mathematical operations, and developed a sense of personal efficacy and intrinsic interest in arithmetic activities” (p. 586). In the same study, the use of distal goals had no more effect than the use of no goals.

The specificity of a goal plays an important role in the achievement of that goal. Note that a lack of specificity would serve to confuse the process of self-observation and self-judgment. Thompson, Meriac, and Cope (2002) provided online learners with either a general goal of “do your best” or a specifically quantified goal in an Internet search task. Participants with the specific goal worked on the task longer than those with the less specific goal. In addition to specificity, the source of the goal is an important issue.
Self-set academic goals have been shown to be more motivating than externally determined goals. Zimmerman, Bandura, and Martinez-Pons (1992) found that students’ self-efficacy beliefs for self-regulated learning affected their academic goals and achievement. The connection between self-efficacy for self-regulated learning was mediated by self-efficacy for academic achievement, which significantly impacted the students’ grade goals. Of particular interest in this study was that the students’ goals were a more important indicator of achievement than the goals set by the students’ parents; empirically demonstrating a phenomenon observed by parents and teachers frequently. One should note how the Zimmerman, Bandurda, and Marinez-Pons (1992) study is yet another example of how self-efficacy and self-regulation are interdependent. In this study the grade goals of the students and parents was a factor. This is an example of the next and final characteristic of goals, goal orientation.

Goal orientation refers to the “type of standard by which individuals will judge their performance or success” (Pintrich & Schunk, 1996, p. 234). Goal orientation has been studied extensively in the literature (e.g. Ames, 1992; Dweck & Leggett, 1988; Maehr & Midgley, 1991). Two goal orientations can be identified from the various terminology used. The language of Ames (1992) adopted by Driscoll (2000) will be used in this discussion: performance goals and learning goals. Students operating with performance goals set standards of success based on external judgments such as test scores, rewards, or performances relative to their peers. Learning goals are those goals that students set for intrinsic reasons such as improving understanding, learning, or succeeding at a challenge. Driscoll summarizes that “performance goals foster the belief that intelligence is fixed” (p. 309) whereas “learning goals are associated with the belief that intelligence is malleable and can be developed” (p. 309). From these descriptions one can see the importance of leaning goals for self-regulation. If a student
believes that intelligence is fixed, then adapting, or regulating, one’s learning to improve achievement would not change academic outcomes. On the other hand, if a student believes that intelligence is malleable, then that student may believe it is possible to control, or regulate, one’s learning. In fact, these distinctions are found in the literature (Ames, 1992; Maehr & Midgley, 1991; Malpass et al., 1999).

The preceding sections on self-regulation have developed the construct of self-regulation and described how it is critically linked to self-efficacy. Bandura (1986) delineates the relationship between self-efficacy and self-regulation well:

People’s judgments of their capabilities, in turn, affect their aspirations, how much effort they mobilize in pursuit of adopted goals, and how they respond to discrepancies between their performances and what they seek to achieve. (p. 470)

Now, let us turn to a discussion of how learners respond to discrepancies in their knowledge by considering self-regulated learning strategies.

**Self-regulated Learning Strategies**

Various authors have identified strategies or processes used by self-regulated learners. McCombs (1986) discussed maintaining attention, planning, monitoring, and self-evaluations. In the context of expert learners Ertmer and Newby (1996) identified three components for self-directed learning: planning, monitoring, and evaluating. Zimmerman and Martinez-Pons (1986; 1988) conducted a series of studies to create and validate a model of student self-regulated learning strategies. The themes of McCombs (1986) and Ertmer and Newby (1996) can be seen in the work of Zimmerman and Martinez-Pons. Given the rigor evident in their developmental work, the strategies identified by Zimmerman and Martinez-Pons (1988) will be used in this
discussion. Their specific strategies are listed in Table 2. Table 2 also illustrates how a learner might enact these strategies and classifies the components of self-regulation, self, behavior, or environment that are represented by each strategy.

Table 2

*Self-regulation Strategies, Possible Action, and Component of Self-Regulation Reciprocity*

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Possible Use by Learner</th>
<th>Component of Reciprocity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-evaluating</td>
<td>I check my work to make sure I did it right</td>
<td>Behavioral regulation</td>
</tr>
<tr>
<td>Organizing and transforming</td>
<td>I make an outline</td>
<td>Self or personal regulation</td>
</tr>
<tr>
<td>Goal-setting and planning</td>
<td>I start studying two-weeks in advance and pace myself</td>
<td>Self or personal regulation</td>
</tr>
<tr>
<td>Seeking information</td>
<td>I go to the library to get as much information as I can</td>
<td>Environmental Regulation</td>
</tr>
<tr>
<td>Keeping records and monitoring</td>
<td>I took notes in class; I keep a list of the words I get wrong.</td>
<td>Behavioral regulation</td>
</tr>
<tr>
<td>Environmental structuring</td>
<td>I turn off the radio so I can concentrate.</td>
<td>Environmental Regulation</td>
</tr>
<tr>
<td>Self-consequating</td>
<td>If I do well on a test, I treat myself to a movie.</td>
<td>Behavioral regulation</td>
</tr>
<tr>
<td>Rehearsing and memorization</td>
<td>I keep writing down a formula until I remember it.</td>
<td>Self or personal regulation</td>
</tr>
<tr>
<td>Seeking social assistance</td>
<td>I ask a friend or teacher for help.</td>
<td>Environmental Regulation</td>
</tr>
<tr>
<td>Reviewing records</td>
<td>Reviewing notes</td>
<td>Environmental Regulation</td>
</tr>
</tbody>
</table>

Ley and Young (2001) suggest four instructional principles that should assist less expert learners with the adoption of these self-regulation strategies:

“guide learners to prepare and structure an effective learning environment, organize instruction and activities to facilitate cognitive and metacognitive processes, use instructional goals and feedback to present student monitoring opportunities, and provide learners with continuous evaluation information and occasions to self-evaluate.”

(p. 94–95).

Ley and Young offer these principles for any instructional situation regardless of delivery method or teaching method. Embedding opportunities for students to develop self-regulation strategies is important in the design of instruction. Pintrich (1999) stresses the importance by stating, “self-regulatory strategies are not easily developed or learned and there must be instruction and scaffolding of these strategies” (p. 469). Additionally, Pintrich indicates that researchers should investigate self-regulated learning in various contexts and study how classroom practices can be changed to cultivate self-regulation. Since that writing in 1999 the classroom and context of many educational endeavors has been the Internet. Self-regulation in web-based learning environments will be addressed next.

**Self-regulation in Web-based Learning Environments**

Whipp and Chiarelli (2004) recently concluded that few research studies have addressed self-regulation of learning in web-based courses. This claim does seem to have merit, thus this review begins with learner self-regulation in computer-based instruction, which is similar in many respects to web-based instruction.
Early research on learner self-regulation in computer-based instruction addressed questions of learner control over computer-based instructional modules. Tennyson, Park, and Christensen (1985) investigated the effects of the length of time that examples in instructional materials were displayed to the learners. The researchers concluded that an adaptive-controlled model for displaying the examples was superior to a learner-controlled model. The participants’ lack of strategies to manage their learning environment was listed as a possible explanation for this observation. Young (1996) came to similar conclusions. Young’s experiment used either program-control or learner control over a computer-based instructional unit on propaganda in advertising. He found that using program control minimized the performance differences between high and low self-regulatory learners. This led him to the conclusion that students in learner-controlled, computer-based instruction require strong self-regulatory skills to succeed.

As the Internet gained popularity and acceptance, the focus of self-regulation research shifted from the context of computer-based instruction to web-based, or hypermedia instruction. Generally, researchers have found various subsets of the strategies identified in the Zimmerman and Martinez-Pons (1988) study to be important for web-based learners. Self-efficacy for Internet use and self-regulation are often mentioned as important characteristics of web-based learners.

Hill and Hannafin (1997) found that participants with more self-reported prior knowledge of the subject material or self-efficacy for using the World Wide Web used more self-regulation strategies than the participants lacking in those characteristics. These observations would indicate that those learners with prior knowledge of the subject and high self-efficacy beliefs regarding Internet use would have more time to devote to learning the task at hand. The
researchers found that monitoring one’s learning in the web-based environment was a critical skill to possess.

In their review of literature, Cennamo and Ross (2000) identified five strategies used most often by students with high levels of self-regulation: keeping records and monitoring, reviewing notes, organizing and transforming, seeking information from nonsocial sources, and seeking teacher assistance. In the context of a web-based child development course designed to foster self-regulation, Cennamo and Ross found that the most effective strategies to support self-directed learning were reviewing notes, keeping records, and self-evaluating. They note that the absence of seeking information from social sources and teacher assistance from this list of effective strategies may be due to the solitary nature of many learners in web-based environments.

Joo, Bong, and Choi (2000) found that self-efficacy for self-regulated learning significantly related to student confidence both in classroom learning and using the Internet. Self-efficacy for self-regulated learning related significantly to Internet self-efficacy, but self-regulation strategy use did not relate to performance. The authors hypothesize that this was possibly due to the self-report nature of self-regulation strategy used in their study.

Other recent studies have found self-regulation components to be important elements of success for web-based learners. Shih and Gamon (2001) studied the relationships of student motivation, attitude, learning styles, and achievement in a web-based course. Motivation was the only factor in their study that related significantly to achievement. Shih and Gamon used less specific measures of motivation than other researchers. However, the top three rated questions on their motivation survey indicated that their participants wanted to get better grades than their classmates; believed they could do well in the class; and that they could do better, if they studied
appropriately. Note that each of these statements could be classified as either a self-regulation strategy or positive self-efficacy belief. Thompson, Meriac, and Cope (2002) had participants engage in an Internet search task. Much like Shih and Gamon (2001), Thompson, Meriac, and Cope determined that elements of self-regulation and self-efficacy were important characteristics of a successful learner. Specifically, participants who had goals worked longer at their task than those with no goals, and participants with higher Internet self-efficacy performed better than those with low Internet efficacy scores. Self-regulation skills were once again found to be important in a hypermedia environment by Azevedo, Guthrie, and Seibert (2004). Azevedo, Guthrie, and Seibert investigated college students’ abilities to regulate their learning while using a hypermedia environment to learn about the human circulatory system. They found that learners who showed an increase in knowledge were those students who regulated their learning with specific strategies such as setting goals, monitoring their learning, and planning. In a study designed with a qualitative approach, Whipp and Chiarelli (2004) found that successful learners in a web-based course used self-regulatory strategies, but that they had adapted them specific to the context of the web-based course. For example, students planned daily logons to the course as a way of keeping up with the course. These logons could be classified as monitoring, goal setting, or planning activities. The students also would use the postings in a threaded discussion to monitor their levels of interaction compared to others and the students used the online gradebook to check their grades; both are web-specific adaptations of self-monitoring and record keeping.

Thus far, evidence has been put forth that demonstrates a positive relationship between success in web-based learning and learners’ ability to self-regulate. Learners that possess self-regulatory skills succeed. When learners have not been successful, a lack of self-regulatory
skills has been shown or suspected. Design practices have been suggested to support and foster learners’ self-regulatory skills. Recently, research has shown that training in self-regulated learning strategies can help students succeed in hypermedia environments (Azevedo & Cromley, 2004).

It seems clear that self-regulation is an important aspect of learning in web-based environments. Research indicates that building self-regulatory scaffolding into web-based courses or simply providing instruction on self-regulation can be effective components of a course. Given the link between self-regulation and self-efficacy, designers wishing to increase either should address both constructs so that their target learners can possibly reap many benefits.

Summary and Conclusions

Self-efficacy has proven to be an important construct for academic achievement in traditional learning environments. Its importance has been consistent over a period of several decades, through all levels of the educational process, with various student populations, and in varied domains of learning. In particular, research specific to mathematics self-efficacy and computer self-efficacy has been set forth in this review, demonstrating the salience of both of these constructs to mathematics achievement and the use of computers.

The role of self-efficacy and academic achievement in online learning environments, however, is not understood. This gap in the literature is critical given the growing prominence of online learning. Several questions need to be addressed regarding self-efficacy in online learning environments. Enactive mastery experiences, vicarious learning, verbal persuasion, and physiological arousal appear to be the four primary sources of self-efficacy in traditional learning environments. Are these the primary sources in online environments? If so, how can elements
of online courses be designed to increase the self-efficacy beliefs of online learners? What
technologies and strategies can be used successfully to increase self-efficacy in online learners?
Is increased self-efficacy for online learning related to achievement in online courses? New
research is needed to answer these questions. Additionally, in the context of traditional learning
environments, mathematics self-efficacy has received much attention in the research literature,
but no studies of mathematics self-efficacy in an online environment could be found for this
review. Is mathematics self-efficacy an important factor in learning mathematics online?

If self-efficacy proves to be an important element for success in online courses, new
online courses can be designed with self-efficacy considered from the beginning of the design
process. But, how can the multitude of existing online courses be redesigned to address the self-
efficacy needs of their learners? Instructional designers should give particular attention to
technologies that are already accepted by learners and educational practitioners, and can be
implemented with low overhead in such courses. One promising approach is the use of email.

In a traditional face-to-face course enhanced by the use of certain web-based
technologies, Frey, Yankelov, and Faul (2003) found that email communication with an
instructor was perceived by students as the most valuable means of online communication.
Jackson (2002) observed an increase in student self-efficacy and performance in an experiment
using an email treatment with students in a traditional introductory psychology course. Jackson
randomly assigned his participants to either a control or an experimental group. Participants
were asked to email him to earn extra credit in the course. He responded to participants in the
experimental group with a note designed to be efficacy enhancing and to control group
participants with a simple acknowledgment informing them that they had received the extra
credit points. The treatment consisted of participants receiving only one email note. Jackson’s
efficacy enhancing email notes tapped on all four of the traditional sources of self-efficacy. Participants in the experimental group displayed a significant increase in self-efficacy compared to the control group, and performance was significantly related to self-efficacy. While Jackson’s study was carefully designed, he did not collect data on the validity of this efficacy enhancing notes, or possible external sources of his participants’ efficacy enhancement. Collecting data on the participants’ perceptions of the email notes, and their interactions with other participants may have revealed sources of confounding efficacy enhancement, and addressed the effectiveness of the email messages as efficacy enhancers. Additionally, Jackson’s use of four strategies of efficacy enhancement in each note did not allow for an analysis of the source of efficacy enhancement that is most effective in email.

A related idea was investigated without the use of email. Visser et al. (2002) concluded that student confidence was increased by using the written word and traditional postal systems to deliver motivational messages to students in a course delivered at a distance. Visser et al. focused a great deal on the perceived intent of their messages. Their general goal was to deliver motivating messages, but they were addressing learner confidence. Confidence is, of course, a central concept for self-efficacy. While research has been conducted using messages, either written or typed in email, to increase learner efficacy, research examining the use of email to increase self-efficacy in asynchronous, online learning environments was not found for this review of literature. Further research regarding the use of email to increase self-efficacy is needed to understand strategies that can increase self-efficacy, and the impact of any observed increases in self-efficacy to academic achievement.

The millions of online learners in existence make it imperative that instructional technology and educational researchers address the questions and issues raised here. Answers to
these questions will provide knowledge to help guide the design of new online courses and focus for improvements to existing online courses. The learning environments designed as a result of these new guidelines will provide online learners with a greater chance for success than in current online offerings.

This review of the literature, coupled with the ever-increasing use of asynchronous learning environments, leads to two questions in need of investigation. Answers to these questions may improve asynchronous learning environments by informing those persons designing them.

Research Questions

The present research is designed to investigate the following research questions:

Question 1: Can efficacy-enhancing email messages enhance students’ self-efficacy for learning math asynchronously?

Question 2: Is there a relationship between self-efficacy for learning math asynchronously and achievement in an asynchronous math course?
Chapter 3: Method

This chapter begins with a description of the experimental designs used to answer the research questions. Following the research design is a description of the research setting, variables, and participants. The materials section includes a discussion of the development of the email treatment and survey instruments including the results of a pilot test of the materials.

Study Design and Variables

The research study was performed using a pretest-posttest control group design. The design is shown in Table 3 using the notation of Campbell and Stanley (1963).

Table 3

Research Design for Research Question 1

<table>
<thead>
<tr>
<th>Experimental Group</th>
<th>(Pre)</th>
<th>(Post)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>O</td>
<td>R</td>
</tr>
</tbody>
</table>

| Control Group      | O    | R     | O     |

Setting

This study was conducted in the context of Virginia Tech’s Math 1015 course. Math 1015 is an asynchronous college algebra and trigonometry course. All course materials and assignments are accessed and completed via the World Wide Web. Students attend an initial face-to-face orientation meeting with the course facilitator who explains the structure and design of the course. After the orientation meeting, there are no required face-to-face, traditional class meetings. The various assignments in Math 1015 have weekly deadlines. Students may study in
any location they choose, but computer-based weekly quizzes, tests, and the final exam must all be taken at the Math Emporium.

The Math Emporium is a computer lab housing over 500 computer workstations in one room. The lab is open 24 hours per day, 7 days per week during the fall semester. Students who choose to study at the Math Emporium can get face-to-face assistance from the math helpers, who are on duty more than 60 hours per week. During this study, the math help staff was comprised of advanced undergraduates, math graduate students, and math faculty members. The course facilitator was available at the Math Emporium several hours each week for individual meetings and one optional 30-minute recitation.

Variables

Independent Variable

One independent variable was manipulated for this study, delivery of efficacy enhancing email notes. Participants in the experimental group received weekly email messages designed to increase their self-efficacy for learning math asynchronously. Control group participants received weekly email messages as well. The messages for the control group were designed to be neutral, and thus, not efficacy enhancing.

Dependent Variables

Two dependent variables were measured for this study: Self-efficacy for learning mathematics Asynchronously (SELMA) and Math Achievement. SELMA data was collected via web survey and was a continuous variable. The value of Mathematics achievement was each student’s highest score on the second test in Math 1015 and was a continuous variable. It was the policy in the course to allow each student two attempts at each test. The tests have a high
degree of randomization. Each test delivered covered the same course material, but consisted of questions unique to each test instance.

Participants

Approximately 1300 students enrolled in Virginia Tech’s Math 1015 course for the fall 2005 semester were invited to participate in the study during a face-to-face orientation session for the course. Participants were informed that they had to be 18 years of age or older and enrolled in Math 1015 to participate. A lottery drawing for a $100 cash prize was offered as an enticement for students to enroll in, and complete, the study. One hundred ninety-six students (143 female, 53 male) initially chose to enroll in the study. These initial participants were randomly assigned to either a control or an experimental group. Each group consisted of 98 participants. SPSS software was used for the random assignment procedure. Five participants resigned from the Math 1015 course for unknown reasons. Sixty-six students did not complete all of the instruments for the study leaving 125 participants who completed every question of every instrument. The final control and experimental groups consisted of 57 (n=17 male, n=40 female) and 68 (n=14 male, n=54 female) participants respectively. The average age of participants completing the study was 18.21 years. Eighty-one percent (n=101) of the participants listed their ethnicity as white with black, other, Asian, and Hispanic being listed by 6 percent (n=8), 6 percent (n=7), 4 percent (n=5), and 2 percent (n=3) of the respondents respectively. One participant did not list ethnicity. Ninety-six percent (n=120) of the participants had no prior experience with online math courses. Fifty-nine of the participants were majoring in the academic fields: biology (n= 20), communications (n=8), psychology (n=15), and history (n=7). Seventy-five participants had undecided academic majors (n=30) or listed their majors as other (n=45). Ninety percent (n=112) of the participants reported their
academic level as *freshman*, with *sophomore, junior*, and *senior* being reported by 6 percent (*n*=8), 3 percent (*n*=4), and 1 percent (*n*=1) of the respondents respectively. When possible, the largest number of respondents completing the instruments in their entirety was used for analyses.

**Materials**

Three surveys were developed for this study: the Self-efficacy for Learning Math Asynchronously (SELMA) survey (Appendix B), a demographics survey (Appendix D), and an exit survey (Appendix E). The exit survey was developed to collect information regarding the participants’ interaction with the Math Emporium staff and their perceptions of the email messages used in the study. A pilot test was conducted from January 17 to February 4, 2005 to test procedures and obtain feedback on the SELMA instrument and treatment email messages. The process used to develop the SELMA instrument and email messages will now be described along with the results of the pilot test.

*Self-efficacy for Learning Mathematics Asynchronously (SELMA) Instrument*

The process used to create the SELMA instrument was patterned after the processes used to develop several other self-efficacy instruments (Delcourt & Kinzie, 1993; Finney & Schraw, 2003; Miltiadou & Yu, 2000; Murphy et al., 1989). The literature was consulted as a first step in constructing the SELMA instrument. Bandura (1986, 1997) recommended that self-efficacy scales be constructed so that they are as specific to the context in which they will be used as possible. This recommendation has been corroborated in the research literature (Multon et al., 1991; Pajares & Miller, 1995). As a second step in the instrument creation process, one-on-one interviews were conducted with faculty and students to gain the specificity suggested in the
literature. The interviews were centered on the participants’ views regarding what skills or knowledge students need to possess in order to be confident that they can succeed in an asynchronous math course. Three Virginia Tech math faculty members who were currently teaching or had recently taught asynchronous math courses were interviewed. Additionally, the facilitator for Math 1015 during the fall 2004 semester identified 784 successful Math 1015 students as possible interviewees. The facilitator considered students successful who had earned a 72 percent or better average in the course at the time the list was constructed. Each of the students on the list was sent an email message inviting them to participate in an interview. Seventeen students responded to the initial email (Appendix A) regarding the interview. Five of the seventeen respondents were able to schedule interviews and participated in interview meetings.

The feedback from these interviews was used to create the survey items used. In some cases, survey items were adapted from existing self-efficacy instruments identified in the review of literature. The interviews revealed that self-efficacy to learn math asynchronously consisted of academic self-efficacy beliefs, self-efficacy beliefs regarding the use of technologies such as email and web browsing, self-regulation, and basic beginning course content skills. After assembling the survey, the fall 2004 Math 1015 facilitator was asked to review the survey and she judged it as an appropriate instrument. The instrument includes items such as, “I would feel confident reading explanations of math homework problems from a web site.”, and “I would feel confident sending an email message to my math teacher.” The process used to construct the SELMA survey provided content validity for the instrument. The complete instrument created for pilot testing is listed in Appendix B. Data collected during the first administration of the SELMA in the pilot study were used for reliability analysis. SPSS version 11 for the Macintosh
was used to calculate the alpha reliability of the survey. An alpha reliability level of 0.87 was obtained and could not be improved through the deletion of items. For the main study, data collected during the August 2005 administration of the SELMA was used for reliability analysis. An alpha reliability level of 0.8573 was obtained using the participants (n=177) who had completed the instrument in its entirety. The reported reliability is slightly less than the reliability obtained during pilot testing, but is still greater than the 0.80 level recommended as a minimum by Gable and Wolf (1993) for instruments in the affective domain.

*Developing the E-mail Messages*

The process of developing the email notes to be used in the study began with a search of the literature. Bandura (1986, 1997) advised that communication with the purpose of enhancing self-efficacy focus on gains and not deficiencies, that persuasory appraisals be just beyond the current performance of the individual to which they are addressed, and that the credibility of the persuader is key. Researchers (Schunk, 1983a; Schunk & Rice, 1986) also have found that feedback regarding ability rather than effort is more effective at enhancing self-efficacy. Examples of efficacy enhancing feedback were found in the literature (Jackson, 2002; Schunk, 1983a; Tuckman & Sexton, 1991) and used as models for the email messages used in this study.

After reviewing the literature, Virginia Tech students and teachers involved with asynchronous math courses during the fall 2004 semester were interviewed. The teachers were asked what type of feedback they provide to their students. The students were asked what type of feedback they receive from their teachers in both traditional and asynchronous math courses. Additionally, students were asked what type of feedback they consider to be encouraging.
The guidance and examples from the literature were combined with data collected from the students and teachers to develop the series of efficacy enhancing email messages such as:

- Fantastic! You did well on Math 1015 quiz [quiz number]; earning a perfect score. Try to match this score next week.
- Very nice! You correctly answered all but one question on Math 1015 quiz [quiz number]. Set aside enough time to study math next week and try for a perfect score.

Appendix C contains the complete list of messages. The messages for the experimental group were designed to address self-efficacy and self-regulation. Self-efficacy was addressed in the note by using praise and positive comments. Time management and goal setting were used as the self-regulatory components of the messages. Also, the mere existence of the messages could have served as a monitoring function to assist with self-regulation. The credibility of the researcher was established in his introduction to the students. The researcher has over seven years experience working with the asynchronous course used for the study. His experience with the course should have addressed the credibility of the researcher from the perspective of the participants.

The course facilitator for Math 1015 in the fall 2004 semester felt strongly that the control group participants receive weekly email messages rather than no message. The rationale was to avoid “compensatory rivalry or resentful demoralization” (Pedhazur & Schmelkin, 1991, p. 228) between members of the control and experimental groups. Since the students in the control and experimental groups may discuss the course, it was believed that they might notice if certain students were receiving email messages and others were not. The neutral email messages were designed to have no effect on self-efficacy or self-regulation. Wording was avoided that
could be interpreted as positive feedback or suggestive of self-regulation strategies. Neutral messages were chosen that provided information about specific details regarding the Math Emporium, but not about the Math 1015 course. A complete list of neutral messages is included in Appendix C. All neutral messages involved simple information about the Math Emporium, for example: “Wireless network access is available for your laptop computer at the Math Emporium. Access to electrical power for your laptop is limited at the Math Emporium. Check the Math Emporium use policy for details on accessing power for your laptop.” Next is a discussion of a pilot test of the messages and instruments.

**Pilot Testing**

Pilot testing was performed to shape the SELMA instrument, test procedures, and obtain feedback on the email messages designed to be efficacy enhancing.

Students enrolled in Virginia Tech’s Math 1015 course during the spring 2005 semester were verbally invited to participate during the face-to-face orientation meeting for the course. Students were told that by completing the pilot study they would be eligible for a drawing for a cash prize. The students who chose to participate were asked to follow a web link on the Math 1015 home page. That web link led them through a web-based informed consent form (Appendix F) followed by a web-based survey to collect demographic information (Appendix D), and finally the web-based SELMA instrument (Appendix B). An email invitation was sent to all Math 1015 students as a reminder about the opportunity to participate in the study. The email invitation contained the web link directing them to the web-based forms and surveys. Participants in the pilot study were 40 (27 female, 13 male) Math 1015 students. Their mean age was 20.4 years and 68 percent (n=28) had never taken an online math course. Fifty-five percent
Self-efficacy, Motivational Email, and Achievement

(n = 22) were freshman, 15 percent (n=6) were sophomores, 12.5 percent (n=5) were juniors, and 12.5 percent (n=5) were seniors. Two students did not list their academic level. Students choosing to participate in the pilot study were randomly assigned to either a control or experimental group using SPSS version 11 statistics software for the Macintosh computer. Participants in the experimental group received efficacy enhancing email notes weekly for two weeks. Notes from Appendix C were assigned to students in the experimental group according to the following algorithm:

- If the score on the quiz = 4/4, assign one of the Group A messages
- If the score on the quiz = 3/4, assign one of the Group B messages
- If the score on the quiz = 2/4, 1/4, 0/4, assign one the Group C messages.
- If a student failed to attempt a quiz, then assign one of the Group D messages.
- In all cases, if the score was an improvement over the previous week’s score, then add a sentence regarding improvement from Group E.

Notes were assigned so that each message from each group of messages was used at least once each week. Students in the control group received weekly notes designed to not enhance efficacy from Group F. The software, MaxBulk Mailer version 3.4 (Max Programming, 2004) was used to send the individually addressed and personalized notes.

After two weeks, participants completed the SELMA instrument for a second time and an exit survey (Appendix E). The exit survey was designed to capture the participants’ perceptions of the nature of the email notes and their interaction with their peers and Math Emporium staff. Thirty-one participants completed the pilot study. It is known that exactly 2 of the 9 students who did not complete the pilot study withdrew from the course. It is not known why the remaining 7 did not complete the pilot.
An open-ended survey (Appendix E) was administered online to the students completing the pilot study to obtain feedback on the email notes. The survey consisted of sample email messages used during the pilot study. Exactly one message from each category of messages created was included on the survey. Participants were asked to read each sample note and then respond with a few words as to what they believed was the underlying purpose of the message. A summary of the participants’ comments is provided in Table 4.
Table 4

*Summary of pilot participant perceived purpose of email notes, 31 possible respondents*

<table>
<thead>
<tr>
<th>Sample Message</th>
<th>Message Intent</th>
<th>Participant Perceived Intent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent! You correctly answered every question on quiz 2 in Math 1015. Aim to do the same next week.</td>
<td>Enhance Efficacy</td>
<td>21 respondents listed: encouragement, motivation, confidence, or congratulations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7 respondents listed: “keep it up”</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No respondents listed a negative intent</td>
</tr>
<tr>
<td>Your Math 1015 quiz score improved this week. Nice job! You got all but one question correct on Math 1015 quiz 3. Be sure to budget enough time for Math 1015 so that you can do that well; or even better; next week.</td>
<td>Enhance Efficacy</td>
<td>23 respondents listed: encouragement, motivation, or confidence</td>
</tr>
<tr>
<td></td>
<td>Regulation</td>
<td>5 respondents listed time management concepts</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 respondent listed “annoying”</td>
</tr>
<tr>
<td>You might not have scored as well on your last Math 1015 quiz as you desired. Check out the many resources available to you on the course web site; and arrange enough time in your schedule next week to study math. Strive to get at least one more quiz question correct on your next quiz.</td>
<td>Enhance Efficacy</td>
<td>12 respondents listed: confidence, encouragement, or motivation</td>
</tr>
<tr>
<td></td>
<td>Regulation</td>
<td>12 respondents listed: information/help regarding course resources</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 respondents listed time management concepts</td>
</tr>
<tr>
<td>You did not take Math 1015 quiz 3. Be sure to budget enough time in your schedule next week for math so that you make your deadline.</td>
<td>Regulation</td>
<td>17 respondents listed time management</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5 respondents listed motivation/encouragement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 respondents listed reprimand</td>
</tr>
<tr>
<td>Each week the Math Emporium web site lists announcements and information important for all Math Emporium users. Check that page regularly.</td>
<td>Neutral – no efficacy or regulation effect intended</td>
<td>16 respondents listed “information”</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8 respondents listed class related deadlines and time management issues</td>
</tr>
</tbody>
</table>
The observation that more than one quarter of the participants perceived the *neutral* message as pertaining to class related time management issues induced a reconsideration of the neutral email messages for the control group. Two of the four neutral email messages used in the pilot contained references to webpage announcements. The webpage announcements referred to were general announcements intended for all users of the Math Emporium. However, the pilot study revealed that such references might be interpreted as course related. Thus, the two ambiguous neutral messages were replaced before using them or administering the surveys for the main study. The actual messages used are reflected in the list of neutral messages provided in Appendix C.

The exit survey (Appendix E) also collected data on the nature of the participants’ interactions with peers, Math Emporium staff, and the course facilitator. Twenty-nine of the 31 respondents reported asking friends for assistance with math 1015 problems *never* (19 responses) or *a few times* (10 responses). Those that did ask their friends for help found the interaction to have an encouragement component. Only three of the 31 respondents had ever asked the course facilitator for assistance. The three participants indicating that they had asked the course facilitator for assistance remarked that the interaction had an element of encouragement. Similarly, few participants had asked the Math Emporium helper staff for assistance. Seven participants indicated they had asked for help *a few times* and one participant had asked for help regularly. Eight of those who had asked the staff for help found the interaction to have an encouragement component.

These responses suggest that confounding sources of efficacy enhancement will not come from interactions with the Math Emporium staff or course facilitator, but perhaps marginally from friends.
Procedures

The procedures followed during the pilot study were used for the main study with the exception of the number of weeks of the treatment and the collection of the Math Achievement data. The informed consent form used in this phase of the study is listed in Appendix H. The treatment and control email messages were sent weekly to the participants for the 4-week period from August 29, 2005 to September 23, 2005. Participants were asked in their final email note to complete the SELMA instrument for the second time and to complete the exit survey before attempting Math 1015 Test 2. Math Achievement for each student was that student’s highest score on Math 1015 Test 2, which was collected from the course facilitator’s electronic records. Dates of submission for the final surveys and the test were checked to verify that the students had indeed responded to the surveys before attempting their test.
Chapter 4: Results

This study was conducted to investigate the following two research questions:

Question 1: Can efficacy enhancing email messages enhance students’ self-efficacy for learning math asynchronously?

Question 2: Is there a relationship between self-efficacy for learning math asynchronously and achievement in an asynchronous math course?

All of the analyses presented in this chapter were performed on the data collected for the main study, which took place in August and September of 2005. An alpha level of 0.05 was used to determine statistical significance in all tests.

Data Analysis

The study was designed for question 1 to be answered using analysis of covariance, ANCOVA. The independent variable measured was the composite score from the post-treatment administration of the self-efficacy for learning mathematics asynchronously (SELMA) instrument. The covariate used was the composite score from the pre-treatment administration of the SELMA. Participants were grouped as either members of the control group or members of the experimental group. The mean composite scores for the post-treatment administration of the SELMA for the control and experimental groups were 119.11 and 119.62 respectively. Critical assumptions for ANCOVA are homogeneity of variance between the treatment groups, and homogeneity of regression coefficients between the dependent variable and covariate. Levene’s test of equality of error variances yielded no significance, \( F(1,124)= 0.427, p = 0.515 \). Thus, the assumption of equal variances was satisfied. The results of the ANCOVA are summarized in Table 5. The non-significant interaction between the group and covariate variable, pre-SELMA
(G x S) indicates the homogeneity of regression coefficients assumption is satisfied. No significant difference in post-treatment SELMA scores was found between the treatment and control groups. That is, no significant difference in self-efficacy scores was detected between the group that received the email messages intended to enhance self-efficacy and the group that received the neutral email messages. The significance shown in Table 5 for pre-SELMA indicates that the use of the pre-treatment SELMA scores as a covariate was valid.

Table 5

*Analysis of Covariance for Research Question 1 (n = 125)*

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>F</th>
<th>η^2</th>
<th>p</th>
<th>Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group (G)</td>
<td>1</td>
<td>.912</td>
<td>.007</td>
<td>.341</td>
<td>.157</td>
</tr>
<tr>
<td>pre-SELMA</td>
<td>1</td>
<td>87.76*</td>
<td>.420</td>
<td>.000</td>
<td>1.000</td>
</tr>
<tr>
<td>G x S</td>
<td>1</td>
<td>.773</td>
<td>.006</td>
<td>.381</td>
<td>.141</td>
</tr>
<tr>
<td>Error</td>
<td>121</td>
<td>(116.04)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note. Value enclosed in parentheses represents mean squares error. *p<.05.*

Research question 2 was answered using simple linear regression. Analysis of variance $F(1,124)=12.543$, $p=.001$ shows a significant linear relationship exists between math achievement and post-treatment SELMA scores. The results of the regression are summarized in Table 6. The $r^2$ value of .093 indicates that self-efficacy to learn mathematics asynchronously explains 9 percent of the variance in math achievement. Using the guidelines of Newton and
Rudestam (1999, p.264), this relationship is classified as a weak positive relationship between post-treatment SELMA and math achievement.

Table 6

*Summary of Regression Analyses for Self-Efficacy to Learn Mathematics Asynchronously (SELMA) Predicting Math Achievement (n = 125)*

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>SE B</th>
<th>( \beta )</th>
<th>( p )</th>
</tr>
</thead>
<tbody>
<tr>
<td>SELMA</td>
<td>.270*</td>
<td>.076</td>
<td>.304</td>
<td>.001</td>
</tr>
</tbody>
</table>

*Note. *\( p < .05. r^2 = .093 \)*

An exit survey (Appendix E) was administered online to the participants to obtain feedback on the email notes. The survey consisted of sample email messages used during the study. Exactly one message from each category of messages developed for the study was used on the survey. Participants were asked to read each sample email message and then respond with a few words as to what they believed was the underlying purpose of the message. A summary of the participants’ comments is provided in Table 7. The messages represented in the first two rows of Table 7 show that the intended purpose of the messages and the intent perceived by participants in the study are in agreement. Agreement between the intended purpose and the perceived intent also can be seen in the messages represented in the last two rows of Table 7. Agreement between the intended purpose and the perceived intent of the remaining type of message is, however, not clear. During the study only 21 percent of the email messages sent to
participants in the experimental group were of this type. Thus, 79 percent of the email messages sent to participants in the experimental group were perceived as intended.
Table 7

Summary of participant perceived purpose of email notes, 161 possible respondents

<table>
<thead>
<tr>
<th>Sample Message (Number Sent)</th>
<th>Message Intent</th>
<th>Participant Perceived Intent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent! You correctly answered every question on quiz 2 in Math 1015. Aim to do the same</td>
<td>Enhance Efficacy</td>
<td>107 respondents listed: encouragement, motivation, confidence, or congratulations</td>
</tr>
<tr>
<td>next week. (153)</td>
<td></td>
<td>34 respondents listed: praise, compliment, reinforce or other positive perception</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No respondents listed a negative intent</td>
</tr>
<tr>
<td>Your Math 1015 quiz score improved this week. Nice job! You got all but one question correct</td>
<td>Enhance Efficacy</td>
<td>126 respondents listed: encouragement, motivation, confidence, and similar positive intent</td>
</tr>
<tr>
<td>on Math 1015 quiz 3. Be sure to budget enough time for Math 1015 so that you can do that</td>
<td>Regulation</td>
<td>5 respondents listed time management concepts</td>
</tr>
<tr>
<td>well; or even better; next week. (134)</td>
<td></td>
<td>2 respondent listed negative perceptions such as “annoying”</td>
</tr>
<tr>
<td>You might not have scored as well on your last Math 1015 quiz as you desired. Check out the</td>
<td>Enhance Efficacy</td>
<td>51 respondents listed: confidence, encouragement, or motivation</td>
</tr>
<tr>
<td>many resources available to you on the course web site; and arrange enough time in your</td>
<td>Regulation</td>
<td>59 respondents listed: information/help regarding course resources</td>
</tr>
<tr>
<td>schedule next week to study math. Strive to get at least one more quiz question correct on</td>
<td></td>
<td>9 respondents listed time management concepts</td>
</tr>
<tr>
<td>your next quiz. (81)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>You did not take Math 1015 quiz 3. Be sure to budget enough time in your schedule next week</td>
<td>Regulation</td>
<td>97 respondents listed time management, scheduling, organization</td>
</tr>
<tr>
<td>for math so that you make your deadline. (18)</td>
<td></td>
<td>12 respondents listed motivation/encouragement</td>
</tr>
<tr>
<td>Math Emporium tip: To access the Math Emporium; students must present a valid Hokie Passport</td>
<td>Neutral – no</td>
<td>105 respondents listed information, reminder</td>
</tr>
<tr>
<td>to the check-in staff. Make sure and bring your Hokie Passport with you on each</td>
<td>efficacy or</td>
<td>1 respondent listed time management concept</td>
</tr>
<tr>
<td>visit to the Math Emporium. (392)</td>
<td>regulation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>effect intended</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No respondents listed encouragement-or motivation-related intent</td>
</tr>
</tbody>
</table>
The exit survey also was used to collect data regarding how often participants had asked for help with the course from friends, the teacher, or helpers at the Math Emporium. Additionally, if participants had asked for help, they were asked to report whether or not there was an encouragement component to the interaction with the friend, teacher, or helper. A summary of the data collected on the type of assistance and encouragement is provided in Table 8. Note that the percentages of interactions for which encouragement was a component are comparable between the control and experimental groups. Most of the participants who asked for help felt that there was an element of encouragement to the interaction, but the majority of participants asked for help never or only a few times.
Table 8

Summary of Outside Help and Encouragement by Group and Type of Assistance

<table>
<thead>
<tr>
<th>Help</th>
<th>Asked Friend</th>
<th>Asked Teacher</th>
<th>Asked Helper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (n=57)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never</td>
<td>20</td>
<td>46</td>
<td>27</td>
</tr>
<tr>
<td>A few times</td>
<td>30</td>
<td>10</td>
<td>24</td>
</tr>
<tr>
<td>Regularly</td>
<td>7</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Encouragement</td>
<td>28 (76%)</td>
<td>8 (80%)</td>
<td>16 (53%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Help</th>
<th>Asked Friend</th>
<th>Asked Teacher</th>
<th>Asked Helper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental (n=68)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never</td>
<td>22</td>
<td>57</td>
<td>29</td>
</tr>
<tr>
<td>A few times</td>
<td>36</td>
<td>11</td>
<td>29</td>
</tr>
<tr>
<td>Regularly</td>
<td>10</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>Encouragement</td>
<td>34 (74%)</td>
<td>9 (82%)</td>
<td>23 (61%)</td>
</tr>
</tbody>
</table>

Chi-Square analyses for the control group versus the experimental group on each reported frequency of asking for help and encouragement were performed. Details of these analyses are listed in Appendix I. The analyses indicate that the frequency of assistance requested and perceived frequency of encouragement in each case was independent of the group; control versus experimental.
Post Hoc Analyses

Paired sample t-tests were performed for the control and experimental groups to determine if there was a change in *self-efficacy to learn mathematics asynchronously* as measured by the pre- and post-treatment scores on the SELMA instrument for each group. Significant increases in SELMA scores were observed for both groups. Hence, participants’ *self-efficacy to learn mathematics asynchronously* increased during the study. Details for the t-tests are presented in Table 9.

Table 9

*Paired Sample t-Tests for pre- and post- Self-Efficacy to Learn Mathematics Asynchronously*

Scores by Treatment Group

<table>
<thead>
<tr>
<th></th>
<th>Pre</th>
<th>Post</th>
<th>t</th>
<th>df</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SELMA</td>
<td>SELMA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>114.26, 13.05</td>
<td>119.11, 14.59</td>
<td>-3.28*</td>
<td>56</td>
<td>.002</td>
</tr>
<tr>
<td>Experimental</td>
<td>113.00, 13.26</td>
<td>119.62, 13.55</td>
<td>-4.65*</td>
<td>67</td>
<td>.000</td>
</tr>
</tbody>
</table>

*Note.* *p* < .05

A variety of other post hoc analyses were performed exploring relationships between variables, but no statistically significant relationships were found.
Summary

Research question 1 was analyzed using analysis of covariance. The analysis did not reveal an effect of the treatment email messages on self-efficacy to learn mathematics asynchronously. Regression analysis was used to answer research question 2. The analysis revealed a positive linear relationship between self-efficacy to learn mathematics asynchronously and math achievement with self-efficacy explaining 9 percent of the variance in math achievement. The free-response data collected with the exit survey indicate that the planned intent of the email messages was generally achieved. Chi-square analyses on the data collected regarding type of help and possible confounding sources of efficacy-enhancement revealed no significant difference between the control and experimental groups. Finally, post hoc analyses show that self-efficacy to learn mathematics asynchronously increased for participants in both the experimental and control groups during the study.
Chapter 5: Discussion

This study was conducted to fill a gap in the existing literature on learner self-efficacy in the context of asynchronous learning environments. Email messages were used in an attempt to increase participants’ self-efficacy for learning mathematics asynchronously. Email was selected as the delivery mode for the messages due to the broad acceptance of it by teachers and learners in asynchronous learning environments. The independent variable, delivery of efficacy-enhancing email, was manipulated in the study by providing email notes to control and experimental groups of participants. Email notes designed to enhance self-efficacy to learn mathematics asynchronously were sent to an experimental group of participants, and email notes designed for no efficacy enhancement were sent to a control group. The content of the efficacy-enhancing messages was designed to address Bandura’s (1986, p. 400) verbal persuasion source of self-efficacy. The control group messages were designed to be points of information only. Wording that could be interpreted as positive feedback or suggestive of self-regulation strategies was avoided in the control group messages. Differences in self-efficacy to learn mathematics asynchronously between the control and experimental groups were investigated as well as the relationship between self-efficacy and math achievement.

Efficacy Enhancement

The question of whether efficacy enhancing email messages could enhance students’ self-efficacy for learning math asynchronously was answered by performing an analysis of covariance. The analysis revealed no significant difference between the control and experimental groups on the variable self-efficacy to learn mathematics asynchronously (SELMA). From this finding it can be inferred that the treatment condition of delivery of
efficacy enhancing email did not enhance the level of self-efficacy to learn mathematics asynchronously significantly more than messages sent to the control group.

The email messages designed for the experimental group were developed to enhance the reader’s self-efficacy. Self-regulation feedback was included in the content of the messages due to the interdependence of the constructs of self-efficacy and self-regulation. As was discussed earlier in the review of literature, there are four principal sources of efficacy enhancement: mastery experiences; vicarious experiences; verbal persuasion; and physiological and affective states. Mastery experiences are those experiences where an individual’s efficacy beliefs are changed through successfully performing a particular target task. Efficacy beliefs may be changed vicariously through the observation of a role model performing a task. Verbal persuasion refers to the source of efficacy development where an individual receives encouragement regarding a task to be performed. Finally, physiological and affective states refers to the process of incorporating sensations such as stress, emotion, mood, pain, and fatigue into one’s beliefs regarding the ability to perform a task. The messages consisted of content intended to parallel what learners might be exposed to in the form of verbal persuasion in a face-to-face learning environment. The email messages designed for the control group participants were intended to be neutral with regard to efficacy enhancement.

Visser, Plomp, Amirault, and Kuiper (2002) developed what they termed motivational messages to address a problem of learner confidence in a series of distance learning courses. In that study the learners lacked confidence that they could finish the course due to a perceived lack of time management skill, academic background, or study skills. Visser, et al. asked their participants to describe what they felt the underlying purpose was for the messages they developed. Their respondents listed encouragement, motivation, personal touch, and reminder
of study commitments and they concluded that their messages were effective. The same method was used in the present study to determine what the participants perceived as the purpose of the email messages.

In general, the participants perceived the email messages developed for this study as they were intended. However, the results indicate the email notes sent to students earning 0, 1, or 2 out of a possible 4 on their quizzes were not clearly perceived as efficacy enhancing. A similar observation was made during pilot testing, but since no negative perception to that type of message was observed, the message was not modified. Only 29 percent, of the email notes sent to participants in the experimental group were of this erroneous type. As in the pilot study, the participants in the main study reported no negative intent for this type of message. Hence, these messages probably did not have a negative effect on self-efficacy, but they may not have had the intended, efficacy-enhancing, effects either.

While the email treatment did not have a significant effect on self-efficacy to learn mathematics asynchronously, SELMA scores did increase during the study. Post hoc analysis found that both the control and experimental groups post-treatment SELMA scores were significantly higher than the pre-treatment SELMA scores. As the review of literature indicated, Bandura (1986, p. 399) described enactive mastery experiences as the most powerful source of efficacy enhancement. The participants were in the Math 1015 course for 5 weeks at the time of the post-treatment administration of the SELMA instrument and thus may have developed increased self-efficacy beliefs by simply negotiating the course.
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**Efficacy and Achievement**

Simple linear regression was used to determine if there was a relationship between self-efficacy for learning math asynchronously and achievement in an asynchronous math course. The regression model revealed a significant positive, but weak, linear relationship between *self-efficacy to learn mathematics asynchronously* and *math achievement*. A positive relationship between self-efficacy and academic achievement was expected based on the review of literature conducted for this study. The 9 percent of variance explained by the regression model found in this study is less than what has been observed in other research studies involving self-efficacy and academic performance. Multon, Brown, and Lent (1991) reported in their meta-analysis of thirty-six research studies that self-efficacy explained 14 percent of the variance in academic achievement. When they restricted their analysis to studies involving college-aged participants, self-efficacy explained 12 percent of the variance in academic achievement. In a research study using email messages to enhance self-efficacy, Jackson (2002) found that self-efficacy explained 11.5 percent of the variance in academic performance.

The efficacy-enhancing notes used by Jackson attempted to address each of the four main sources of self-efficacy identified by Bandura (1986): *enactive mastery, vicarious experience, verbal persuasion, and physiological states*. The email notes designed for the present study were designed only to address the *verbal persuasion* form of efficacy enhancement. Bandura notes, “the impact of persuasory opinions on self-efficacy is apt to be only as strong as the recipient’s confidence in the person who issues them” (1986, p. 406). The researcher delivering the efficacy enhancing email notes attempted to build credibility with the participants at the initial face-to-face meetings of the course. However, given the limited amount of time spent with the researcher, and the relative anonymity of email messages in general, there is no way of knowing,
if credibility was established. The focused, verbal persuasion approach of the email notes used in the present study, compared to Jackson’s comprehensive approach, may partially account for the smaller amount of variance explained in the present study, and the fact that Jackson found a significant experimental effect for his email message treatment.

**Sources of external efficacy enhancement**

The participants in the study were in an academic environment that allowed each of them the freedom to work on the course material with friends, or to request assistance from the course facilitator or helpers working in the Math Emporium. Any interaction the participants had with other individuals regarding the Math 1015 course created opportunities for efficacy enhancement from a source other than the treatment email messages. In order to assess the possibility of efficacy enhancement from external sources, the students were asked to respond to questions on an exit survey. The exit survey was used to collect data regarding the frequency of interactions with friends, their teacher, and other math helpers, and to determine whether those interactions involved encouragement. The exit survey results provide evidence that the control and experimental groups did not differ on the amount of external assistance or encouragement received during the study.

**Practical Implications**

The results of this research can be used to inform the administration and design of asynchronous courses such as the one used as the setting for this study. The finding that *self-efficacy to learn mathematics asynchronously* increased during this study reflects well on the design of the course. Failures that occur early in a given situation lower self-efficacy (Bandura,
The fact that an increase in self-efficacy occurred during this study indicates that, overall, the students are building positive self-efficacy beliefs about their ability to succeed in this type of learning environment. Since no experimental effect was found in this study, it is possible that the students are experiencing increased efficacy simply by working through the course. Hence, while there may be areas in which the course could be improved, from a self-efficacy perspective, this course has a positive design. If the trend of increased self-efficacy continues throughout the course, failures later in this, or similar, learning experiences will be less likely to negatively impact their self-efficacy beliefs (Bandura, 1986, p. 399). Given the positive relationship between self-efficacy and achievement found in this study, and the others discussed in the review of literature, developing increased self-efficacy beliefs will likely benefit the students academically.

The data collected on the interaction of the participants with others in their learning environment points to some important items to consider. Although, most of the participants had asked for help from their friends, teacher, or helpers never or only a few times, the majority of participants who interacted with their friends, teacher, or helpers at the Math Emporium found those interactions to have components of encouragement. Encouragement could lead to increased efficacy beliefs. Students may not be receptive to forced interactions, but the course designers and administrators may want to consider ways to make interactions between the students and their peers, teachers, and other helpers more likely to occur. Additionally, none of the participants in this study indicated that they regularly asked their teacher for help, and the majority of the participants indicated they had never asked their teacher for help. As such, the role of the teacher in this asynchronous course may need to be reevaluated.
Limitations of the Study and Areas of Future Research

As is true of all research, this study was limited by certain factors. One limitation of this study involves the technology used to deliver the treatment messages. While none of the messages sent were returned as undeliverable, it is not known how many of the participants in the present study actually read the email messages delivered to them. A simple email receipt was encoded with each note sent for this study, but it was later discovered that the receipt feature is often ignored by email software or disabled by users. Since the announcement regarding the final surveys, including the web link to the surveys, was made exclusively with email, one can be assured only that the participants read the last email message sent to them. Future research utilizing the delivery of email messages should use reliable methods to track what messages are being read. This consideration may be a difficult task to accomplish, but it is necessary to determine if the participants are experiencing the treatment.

A second limiting factor for this research is the generalizability of the findings. This study was conducted in a learning environment that exists in few other places. The Math Emporium environment is beginning to be replicated, but at this writing similar, mature environments are known to exist only at the University of Alabama, the University of Idaho, and West Virginia University. Additionally, the participants for this study were mainly female freshman students who had not previously taken an online math course. Hence, further research is needed to determine the generalizability of the results.

In the present study the delivery of email notes had no significant experimental effect on the self-efficacy beliefs of students to learn math asynchronously. However, positive effects of efficacy enhancing email messages (Jackson, 2002) and motivational messages (Visser, Plomp,
Amirault, and Kuiper, 2002) have been found in prior research. In particular, Jackson used email messages that addressed all four of Bandura’s (1986, p. 399-401) major sources of self-efficacy: enactive mastery experiences, vicarious learning, verbal persuasion, and physiological state. The present study differed from previous research in that it used email messages focusing only on the verbal persuasion source of developing self-efficacy beliefs. Additional research may be needed to determine which of the four sources of developing self-efficacy beliefs is most effective when delivered via email. Given the importance of self-efficacy to academic achievement, and the ever-increasing number of online or asynchronous learners demonstrated earlier in this document, such research would be valuable to educational practitioners and instructional designers.

In the learning environment that was the setting for this study, participants may have had the opportunity to observe peers who were being successful in the course. This may have been a source of increased self-efficacy through vicarious experience, however, no data was collected to investigate this source of efficacy enhancement. Future researchers may find it beneficial to collect data on participants perceptions of their peers’ experiences. Those perceptions may provide insight into how vicarious experiences may be affecting their self-efficacy beliefs toward the course.

A weak positive relationship was found in this study between self-efficacy to learn mathematics asynchronously and math achievement. The finding of a statistically significant, positive relationship between self-efficacy and academic achievement is consistent with the body of literature on these constructs. The body of literature, however, was developed mostly in traditional learning environments. Additional research is needed to confirm that such a relationship exists in online or asynchronous learning environments.
When investigating relationships like those considered in this study, valid and reliable instruments are key to finding meaningful results. Following the guidelines of self-efficacy research, the SELMA instrument was developed with a high degree of specificity for the research setting used in this study. The instrument was developed following procedures and guidelines provided in the research literature, and the instrument was found to have acceptable internal reliability ratings. If the SELMA instrument is believed to be appropriate for uses in future research studies, it should be rigorously tested for validity and reliability for the new research context.

Summary

In conclusion, the treatment email messages designed for this study to enhance the self-efficacy beliefs of students in an asynchronous mathematics course appear to have had no significant effect on self-efficacy. The positive relationship between self-efficacy and academic achievement that has been established in the literature was observed in this study. Since most of the existing research on self-efficacy and academic achievement has been conducted in traditional learning environments, the study presented in this report extends those findings to an asynchronous learning environment. The findings of this research, combined with its limitations, and similar existing research studies offer several areas of future research.
References


Hello [student’s first name],

My name is Charles Hodges. I am a graduate student in the Instructional Technology program at Virginia Tech. You are invited to participate in a research study that will help me understand what skills a student in Math 1015 must have in order to be confident and successful in an asynchronous math course like Math 1015. To participate you simply have to meet me at the Math Emporium for an interview that will take no more than one hour.

No promise or guarantee of benefits will be made to encourage your participation. Your participation will contribute to research that may influence changes in the design of Math 1015 to be implemented in future semesters.

You must be age 18 or over and currently enrolled in Virginia Tech's Math 1015 to participate in this study. Participation is voluntary. Participating or not participating will NOT impact your grade in any way. In fact, data collected from you will never be associated with your name.

If you are willing to meet with me at the Math Emporium for an interview, please respond to me at hodgesc@vt.edu so that we can set up a time to meet.

Thank you for your time and consideration.

Sincerely,

Charles Hodges
Appendix B

Self-efficacy for Learning Mathematics Asynchronously (SELMA) Instrument

Type your Virginia Tech email address in the "email" box below. Use the same email address throughout the study.
Email: _____________________________

Instructions: Please choose the number that best describes how true or false each statement is for you. *There are no right or wrong answers.* Use the following scale for your responses.

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definitely False</td>
<td>Mostly False</td>
<td>A little bit False</td>
<td>A little bit True</td>
<td>Mostly True</td>
<td>Definitely True</td>
</tr>
</tbody>
</table>

When math problems are hard I give up or study only the easy parts. (M)
I work on math practice exercises even when I don't have to do so. (M)
I work hard to earn a good grade even when I do not like a class. (M)
I can plan my school work. (Z)
I do not finish homework assignments by deadlines. (Z)
I can study math when there are other interesting things to do. (Z)
I cannot motivate myself to do my math schoolwork. (Z)
I can organize my school work. (Z)
I would feel confident using a web browser (e.g. Netscape or Internet Explorer). (O)
I would feel confident reading text from a web site. (O)
I would feel confident clicking on a link to visit a specific web site. (O)
I would feel confident accessing a specific web site by typing the address (URL). (O)
I would feel confident reading explanations of math homework problems from a web site. (O)
I would feel confident taking math quizzes and tests using a web browser.
I would feel confident logging on and off an email system. (O)
I would feel confident reading an email message from someone. (O)
I would feel confident sending an email message to someone. (O)
I would feel confident sending an email message to my math teacher. (O)
I would feel confident using email to discuss math homework problems.
I am confident using a hand-held calculator to solve math problems.
I would feel confident using a NON-graphing calculator for my math work.
**Instructions:** Imagine that you have to take a 15-question, multiple-choice test made up of problems like those shown below. **Do not work the problems.**

1) Find all values for $x$ that satisfy the equation \( \frac{4}{x + 1} = \frac{3x + 8}{(x + 1)^2} \).

2) How many real roots does the equation \(-8x^2 + 6x + 8 = 0\) have?

3) According to Poiseuille’s law, the resistance to flow in a blood vessel, $R$, is directly proportional to the length, $L$, of the vessel and inversely proportional to the fourth power of the radius, $r$, of the vessel. If $R = 159.8$ when $L = 24\text{mm}$ and the radius is $0.6\text{mm}$, what is $R$ when the radius is $0.7\text{mm}$ and the length is unchanged?

4) What is the solution to the linear equation \( 5 - (7 + 2\left(\frac{11}{4} - x\right)) = \frac{3}{2} \)?

5) A bacteria culture grows in a laboratory setting. During the first 3 days, the culture count increases from 7236 to 9201 bacteria. Unfortunately, a contaminant enters the lab causing the number of bacteria to increase by only 711 over the next 5 days. What is the average rate of increase of the bacteria count per day for the entire observation period?

6) Solve the following linear inequality \(-8 \leq \frac{1}{6}(27 + 9x) < -7\).
Now use the following scale to answer the questions below. You can select any number from 1 to 6.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not Confident at all</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Completely Confident</td>
</tr>
</tbody>
</table>

How confident are you that you could make a score of 60% or higher on the math test described above? (S)

How confident are you that you could make a score of 70% or higher on the math test described above? (S)

How confident are you that you could make a score of 80% or higher on the math test described above? (S)

How confident are you that you could make a score of 90% or higher on the math test described above? (S)

---

1 M = adapted from Pintrich and De Groot (1990), Z = adapted from Zimmerman, Bandura, and Martinez-Pons (1992), O = adapted from Miltiadou and Yu (2000), S = adapted from Spence (2004)
Appendix C

Treatment Email Messages

Group A: Messages for students correctly answering 4 of 4 quiz questions

Great Job! You earned a perfect score on Math 1015 quiz [quiz number]. Keep doing what you are doing. It works!

Excellent! You correctly answered every question on quiz [quiz number] in Math 1015. Aim to do the same next week.

Perfect! You got all the questions correct on Math 1015 quiz [quiz number]. Keep up the good work.

Fantastic! You did well on Math 1015 quiz [quiz number]; earning a perfect score. Try to match this score next week.

Group B: Messages for students correctly answering exactly 3 of 4 quiz questions

Nice job! You got all but one question correct on Math 1015 quiz [quiz number]. Be sure to budget enough time for Math 1015 so that you can do that well, or even better, next week.

Good work! You got nearly every question Math 1015 quiz [quiz number] correct. Make sure to reserve enough time for Math 1015 to do at least that well again next week.

Very nice! You correctly answered all but one question on Math 1015 quiz [quiz number]. Set aside enough time to study math next week and try for a perfect score.

Good job! You answered three of the four questions on Math 1015 quiz [quiz number] correctly. You only missed one question. Make sure to set aside enough time to study math next week. Strive to get a perfect score next week.

Group C: Messages for students who correctly answer 0, 1, or 2 of 4 quiz questions

You probably did not score as high as you would have liked on your last Math 1015 quiz. For next week’s quiz, budget enough time to make use of the course resources and aim to get at least one more quiz question correct.

If you did not score as well as you wanted on your last Math 1015 quiz, explore the various course resources available. Reserve enough time to study for your next quiz and set a goal of answering at least one more quiz question correctly.
You may not have done as well on your last Math 1015 quiz as you wanted. Investigate the various resources available on the Math 1015 web site. Make sure to plan enough time for studying next week and try to correctly answer at least one more question.

You might not have scored as well on your last Math 1015 quiz as you desired. Check out the many resources available to you on the course web site, and arrange enough time in your schedule next week to study math. Strive to get at least one more quiz question correct on your next quiz.

**Group D: Messages for students who do not attempt a quiz**

You did not take Math 1015 quiz [quiz number] by your deadline. Be sure to budget enough time in your schedule next week for math so that you make your deadline.

You did not take Math 1015 quiz [quiz number] by your deadline. Plan enough time in your schedule next week so that you can make your deadline.

You did not take Math 1015 quiz [quiz number] by your deadline. Arrange enough time in your schedule next week for math so that you make your deadline.

You did not take Math 1015 quiz [quiz number] by your deadline. Reserve enough time to study math next week so that you can make your deadline.

**Group E: Statements Regarding Improvement**

Your quiz score improved this week.
You did better on your quiz this week.
Your quiz score increased this week.
You improved your quiz score this week.

**Group F: Neutral Messages**

Wireless network access is available for your laptop computer at the Math Emporium. Access to electrical power for your laptop is limited at the Math Emporium. Check the Math Emporium use policy for details on accessing power for your laptop.

Math Emporium tip: To access the Math Emporium, students must present a valid Hokie Passport to the check-in staff. Make sure and bring your Hokie Passport with you on each visit to the Math Emporium.

Math Emporium tip: Coin return lockers are available at the Math Emporium to keep your personal items safe. The lockers accept quarters only and are located in the front lounge.

Math Emporium tip: All users of the Math Emporium should read its online Use Policy. Know the rules so you don’t break them by accident.
Appendix D

Demographics Survey

Type your Virginia Tech email address in the “email” box below. Use the same email address throughout the study:[text box]

What is your gender?  
male  female

What is your age in years?  
age [text box]

What is your race/ethnicity?  
Asian  Black  Hispanic  White  Other

What is your current academic level?  
freshman  sophomore  junior  senior

What is your academic major?  
BIOL  COMM  HIST  PSYC  US  other

How many math courses did you have in high school?  
Number of Math Courses [text box]

Did you have Calculus in high school?  
yes  no

Prior to Math 1015, did you ever take an online math course?  
yes  no

What is the highest level of education your mother has completed?  
less than high school  
high school  
some college  
4-year college degree  
Master's Degree  
Doctoral Degree

What is the highest level of education your father has completed?  
less than high school  
high school  
some college  
4-year college degree  
Master's Degree  
Doctoral Degree
Appendix E

Exit Survey

Type your Virginia Tech email address in the "email" box below. Use the same email address you have used throughout the study. email [text box]

Instructions: Below are samples of email notes sent from a teacher to individual students. Read each of the notes and, using a few words, describe what you feel the underlying purpose of each note was in the text boxes provided.

Hi Jane,

Excellent! You correctly answered every question on quiz 2 in Math 1015. Aim to do the same next week.

Message Purpose: [text box]

Hi Kelly,

You did not take Math 1015 quiz 3. Be sure to budget enough time in your schedule next week for math so that you make your deadline.

Message Purpose: [text box]

Hi Jessie,

Your Math 1015 quiz score improved this week. Nice job! You got all but one question correct on Math 1015 quiz 3. Be sure to budget enough time for Math 1015 so that you can do that well, or even better, next week.

Message Purpose: [text box]

Hi John,

Math Emporium tip: To access the Math Emporium, students must present a valid Hokie Passport to the check-in staff. Make sure and bring your Hokie Passport with you on each visit to the Math Emporium.

Message Purpose: [text box]
Hi Bill,

You might not have scored as well on your last Math 1015 quiz as you desired. Check out the many resources available to you on the course web site, and arrange enough time in your schedule next week to study math. Strive to get at least one more quiz question correct on your next quiz.

Message Purpose: [text box]

Instructions: Please respond to the questions below.

How often have you asked a friend for assistance with Math 1015 problems this semester?

never  a few times  regularly

If you have asked a friend for help, did you receive encouraging feedback or simply an answer to a question?

encouragement  answer  both an answer and encouragement

How often have you asked your teacher for assistance with Math 1015 problems this semester?

never  a few times  regularly

If you have asked your teacher for help, did you receive encouraging feedback or simply an answer to a question?

encouragement  answer  both an answer and encouragement

How often have you asked a helper at the Math Emporium who is not your teacher for assistance with Math 1015 problems this semester?

never  a few times  regularly

If you have asked a helper for assistance, did you receive encouraging feedback or simply an answer to a question?

encouragement  answer  both an answer and encouragement
INFORMED CONSENT FOR SPRING 2005

SELF-EFFICACY TO LEARN MATHEMATICS ASYNCHRONOUSLY PILOT STUDY

INVESTIGATOR: Charles Hodges, School of Education, Virginia Tech

RESEARCH ADVISOR: Dr. Katherine S. Cennamo, Ph.D., School of Education, Virginia Tech

I. THE PURPOSE OF THIS RESEARCH PROJECT

This is the pilot phase of a research project. In the pilot phase, survey instruments and email messages will be tested and refined for use in a later phase of the project. The purpose of the eventual research study is to gather information on students’ views regarding their confidence in their ability to be successful in an asynchronous math course. Also of interest is how that confidence is related to math achievement.

II. PROCEDURES

In addition to this form, you will be asked to complete two online surveys at the beginning of your course and two surveys approximately three weeks into the course. You also agree that I may obtain your Math 1015 quiz and test scores from your Math 1015 teacher and that I may send you weekly email messages. The email messages will be related to Math 1015 or the Math Emporium in general.

III. RISKS

There are no anticipated risks to you as a result of participating in this project beyond those experienced in everyday activity.

IV. BENEFITS OF THIS PROJECT

Your participation will contribute to research that may influence the design of asynchronous Math courses like Math 1015. You may find that the surveys and emails help you better understand your own learning. You may contact the researcher at a later time for a summary of the research results.

V. EXTENT OF ANONYMITY AND CONFIDENTIALITY

Your identity in this study will be treated as confidential. Data collected will be kept confidential and only the researchers associated with the project will have access to the data. Information gathered from the project may be used in reports, presentations, and articles in professional journals, however, all data will be pooled and published in aggregate form only. In no case will responses from individual participants be identified. Despite every effort to preserve it, there is a chance that anonymity may be compromised.
VI. Compensation
Participants who complete all four surveys for this pilot study will be entered into a lottery drawing for a cash prize. Exactly one prize of $50 United States currency will be awarded. The random drawing for the prize will be held on February 11, 2005. The winner will be notified by email. If the winner does not respond to the email notification of winning within 72 hours, the prize is forfeited. Chances of winning depend on the number of study participants.

VII. Freedom to Withdraw
You are free to withdraw from this study at any time without penalty to your grades, status, or relations with the Virginia Tech Math Department, School of Education, or Virginia Tech in general. Withdrawing from the study will make you ineligible for the prize drawing. You may withdraw from the study by contacting the researchers (Charles Hodges or Dr. Katherine Cennamo) or by contacting Dr. Barbara Lockee or Dr. David Moore, IRB chair. Contact information for these four individuals is available at the end of this document.

VIII. Approval of Research
This research project has been approved as required by the Institutional Review Board for Research Involving Human Subjects at Virginia Polytechnic Institute and State University, and by the Department of Teaching and Learning.

IX. Subject's Permission
I have read the Informed Consent agreement. I am 18 years of age or older and I have had all my questions answered at this time. I hereby acknowledge the above and give my voluntary consent for participation in this project. If I participate, I may withdraw at any time without penalty by contacting one of the people listed below. I indicate my agreement to participate in this study by entering my email address below and clicking "submit".

To participate in this study type your Virginia Tech email address in the "email" box below and click the "Submit" button. Use the same email address throughout the study.

email [text box]

Should you have any questions about this research or its conduct, you may contact any of the following:

Investigator: Charles B. Hodges Phone: 540-231-2219 [hodgesc@vt.edu]
Faculty Advisor: Katherine S. Cennamo Phone: 540-231-5587 [cennamo@vt.edu]
Department Reviewer: Barbara B. Lockee Phone: 540-231-5587 [lockeebb@vt.edu]
Chair, IRB: David M. Moore Phone: 540-231-4991 [moored@vt.edu]
Office of Research Compliance, Research and Graduate Studies
Appendix G

Email Soliciting Participation in Phase II (Approved by VT IRB, January 2005)

Hello,

My name is Charles Hodges. I am a graduate student in the Instructional Technology program at Virginia Tech. You are invited to participate in a research study designed to investigate students’ views regarding their confidence in their ability to be successful in an asynchronous math course like Math 1015. Also of interest is how that confidence is related to math achievement.

If you choose to participate in this study you will be agreeing to complete five online surveys. Additionally, you agree that I may obtain your Math 1015 quiz and test scores from your Math 1015 teacher and that I may send you weekly email messages. The email messages will be related to Math 1015 or the Math Emporium in general. Your participation will contribute to research that may influence changes in the design of Math 1015 to be implemented in future semesters. You might even find that the surveys and emails help you better understand your own learning. Participants who complete the first four surveys for this and complete Math 1015 exam 2 by the deadline will be entered into a lottery drawing for a cash prize of $100 United States currency.

You must be age 18 or over and currently enrolled in Virginia Tech’s Math 1015 to participate in this study. Participation is voluntary. Participating or not participating will NOT impact your grade in any way. In fact, data collected from you will never be associated with your name.

If you are willing to participate in this study, please proceed by visiting the web page:

<web link to informed consent form>

and complete the survey items prior to **Saturday, August 27, 2005**. The link to participate in the study also is listed on the Math 1015 course web page.

Thank you for your time and consideration.

Sincerely,

Charles Hodges
Appendix H

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

Informed Consent for Fall 2005

Self-efficacy to Learn Mathematics Asynchronously

Investigator: Charles Hodges, School of Education, Virginia Tech

Research Advisor: Dr. Katherine S. Cennamo, Ph.D., School of Education, Virginia Tech

I. The Purpose of this Research Project
The purpose of this research study is to gather information on students’ views regarding their confidence in their ability to be successful in an asynchronous math course. Also of interest is how those views are related to math achievement.

II. Procedures
In addition to this form, you will be asked to complete the following: two online surveys at the beginning of your course, two online surveys prior to taking Math 1015 exam 2, and an online survey at the end of the course. You also agree that I may obtain your Math 1015 quiz and test scores from your Math 1015 teacher and that I may send you weekly email messages up to your Exam 2 deadline. The email messages will be related to Math 1015 or the Math Emporium in general.

III. Risks
There are no anticipated risks to you as a result of participating in this project beyond those experienced in everyday activity.

IV. Benefits of this Project
Your participation will contribute to research that may influence the design of asynchronous Math courses like Math 1015. You may find that the surveys and emails help you better understand your own learning. You may contact the researcher at a later time for a summary of the research results.

V. Extent of Anonymity and Confidentiality
Your identity in this study will be treated as confidential. Data collected will be kept confidential and only the researchers associated with the project will have access to the data. Information gathered from the project may be used in reports, presentations, and articles in professional journals, however, all data will be pooled and published in aggregate form only. In no case will responses from individual participants be identified. Despite every effort to preserve it, there is a chance that anonymity may be compromised.
VI. Compensation
Participants who complete the study through exam 2 will be entered into a lottery drawing for a cash prize. To be entered into the drawing a participant must complete the first four surveys of the study and complete exam 2. Surveys must be completed by the announced deadlines. Exactly one prize of $100 United States currency will be awarded. The random drawing for the prize will be held on October 1, 2005. The winner will be notified by email. If the winner does not respond to the email notification of winning within 72 hours, the prize is forfeited. Chances of winning depend on the number of study participants.

VII. Freedom to Withdraw
You are free to withdraw from this study at any time without penalty to your grades, status, or relations with the Virginia Tech Math Department, School of Education, or Virginia Tech in general. Withdrawing from the study will make you ineligible for the prize drawing. You may withdraw from the study by contacting the researchers (Charles Hodges or Dr. Katherine Cennamo) or by contacting Dr. Barbara Lockee or Dr. David Moore, IRB chair. Contact information for these four individuals is available at the end of this document.

VIII. Approval of Research
This research project has been approved as required by the Institutional Review Board for Research Involving Human Subjects at Virginia Polytechnic Institute and State University, and by the Department of Teaching and Learning.

IX. Subject's Permission
I have read the Informed Consent agreement. I am 18 years of age or older and I have had all my questions answered at this time. I hereby acknowledge the above and give my voluntary consent for participation in this project. If I participate, I may withdraw at any time without penalty by contacting one of the people listed below. I indicate my agreement to participate in this study by entering my email address below and clicking "submit".

To participate in this study type your Virginia Tech email address in the "email" box below and click the "Submit" button. Use the same email address throughout the study.

email [text]

Should you have any questions about this research or its conduct, you may contact any of the following:

Investigator: Charles B. Hodges Phone: 540-231-2219 [hodgesc@vt.edu]
Faculty Advisor: Katherine S. Cennamo Phone: 540-231-5587 [cennamo@vt.edu]
Department Reviewer: Barbara B. Lockee Phone: 540-231-5587 [lockeebb@vt.edu]
Chair, IRB: David M. Moore Phone: 540-231-4991 [moored@vt.edu]
Office of Research Compliance, Research and Graduate Studies
Appendix I

Appendix I consists of the Chi-Square analyses of frequency data collected via the exit survey of study participants. The data was analyzed to determine if there were differences between the control and experimental groups in the frequency of requesting help from friends, their teacher, or helpers at the Math Emporium. Additionally, data was analyzed for independence between the control and experimental group participants for those participants indicating that they had requested assistance from a friend, the teacher, or a helper at the Math Emporium, and the interaction included an encouragement component.

*Frequency of Requesting Assistance Analysis*

For each case the following hypotheses were tested at an alpha level of 0.05.

\[ H_0: \text{The level of external assistance used is independent of grouping (control vs. experimental).} \]

\[ H_a: \text{The level of external assistance used is NOT independent of grouping (control vs. experimental).} \]

Table I1

<table>
<thead>
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<th></th>
<th>Never</th>
<th>A few times</th>
<th>Regularly</th>
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<tr>
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<td>20</td>
<td>30</td>
<td>7</td>
</tr>
<tr>
<td><strong>Experimental</strong></td>
<td>22</td>
<td>36</td>
<td>10</td>
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*Note. \( \chi^2(2, N = 125) = .204, p = .903 \)
Table I2

Control vs. Experimental Frequency for Requesting Assistance from Teacher

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<td>46</td>
<td>57</td>
</tr>
<tr>
<td>A few times</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>Regularly</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Note. $\chi^2 (1, N=124) = .062, \ p = .804$

Table I3

Control vs. Experimental Frequency for Requesting Assistance from Helper

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Control</th>
<th>Experimental</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never</td>
<td>27</td>
<td>29</td>
</tr>
<tr>
<td>A few times</td>
<td>24</td>
<td>29</td>
</tr>
<tr>
<td>Regularly</td>
<td>6</td>
<td>9</td>
</tr>
</tbody>
</table>

Note. $\chi^2 (2, N=124) = .339, \ p = .844$

Summary of Frequency of Requesting Assistance Analysis

In each of the three cases for frequency of requesting assistance no significant findings were revealed. Therefore, the null hypothesis is not rejected for any case.
**Frequency of Perceived Encouragement With Assistance Analysis**

For each case the following hypotheses were tested at an alpha level of 0.05.

**H₀**: The frequency of perceived encouragement is independent of grouping (control vs. experimental).

**Hₐ**: The frequency of perceived encouragement is NOT independent of grouping (control vs. experimental).

Table I4

*Control vs. Experimental Frequency for Perceived Encouragement when asked Friend*

<table>
<thead>
<tr>
<th></th>
<th>Encouragement</th>
<th>No Encouragement</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Control</strong></td>
<td>28</td>
<td>9</td>
</tr>
<tr>
<td><strong>Experimental</strong></td>
<td>34</td>
<td>14</td>
</tr>
</tbody>
</table>

*Note.* $\chi^2(1, N=85) = .248, \ p = .618$

Table I5

*Control vs. Experimental Frequency for Perceived Encouragement when asked Teacher*

<table>
<thead>
<tr>
<th></th>
<th>Encouragement</th>
<th>No Encouragement</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Control</strong></td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td><strong>Experimental</strong></td>
<td>9</td>
<td>2</td>
</tr>
</tbody>
</table>

*Note.* $\chi^2(1, N=21) = .011, \ p = .916$
Table 16

Control vs. Experimental Frequency for Perceived Encouragement When Asked Helper

<table>
<thead>
<tr>
<th>Encouragement</th>
<th>No Encouragement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>16</td>
</tr>
<tr>
<td>Experimental</td>
<td>23</td>
</tr>
</tbody>
</table>

*Note. $\chi^2(1, N=68) = .355, p = .552*

Summary of Frequency of Perceived Encouragement With Assistance Analysis

In each of the three cases for frequency of perceived encouragement no significant findings were revealed. Therefore, the null hypothesis is not rejected for any case.

Summary

These six Chi-Square analyses show that the control and experimental groups were not significantly different on the frequency of type of help or amount of external encouragement received.
EDUCATION

**Ph.D.** Virginia Tech, degree expected December 2005  
Department of Learning Sciences and Technologies  
School of Education, Blacksburg, VA  
Major: Instructional Design and Technology  
Advisor: Katherine S. Cennamo

**M.S.** West Virginia University  
Morgantown, WV  
Degree conferred May 1992  
Major: Mathematics

**B.S.** Fairmont State College  
Fairmont, WV  
Degree conferred May 1990, Cum Laude  
Major: Mathematics  
Minor: Computer Science

PROFESSIONAL EXPERIENCE

**Math Emporium Manager,** Virginia Tech  
August 1998 to present  
Instructor-rank faculty; Responsible for the daily operations of a 530+ station, computer-based learning facility; Manage and train a staff of approximately 60 persons yearly; Organize assignment and test deadlines for multiple courses; Conduct tours; Coordinate facility activities involving multiple University units and external groups; Develop and maintain multiple web-pages; Design, develop, and maintain database driven, web-based tools to support online courses; System Administrator for QuickTime Streaming Server; Create course-related streaming video files; Designed and Developed CRLA certified tutor training program; Member of departmental committees
Instructor of Mathematics, Virginia Tech
August 1994 to August 1998
Responsible for teaching the equivalent of twelve semester hours of college level mathematics courses each semester;
Member of departmental committees

Instructor of Mathematics, Concord College
August 1992 to July 1994
Responsible for teaching a minimum of twelve semester hours of college level mathematics and statistics courses each semester;
Wrote the regional Math Field Day exam; Organized a student chapter of the Mathematical Association of America and served as faculty advisor

Graduate Teaching Assistant, West Virginia University
August 1990 to May 1992
Taught college level mathematics courses and tutored math through the calculus level.

HONORS

Graduate Student of the Year, 2004-2005
Virginia Tech Instructional Technology Student Association

Instructor of the Year, 1998-1999, Virginia Tech Department of Mathematics

XCaliber Award for Academic Program Transformation (team award),
Center for Innovation in Learning, Virginia Tech, 1999

Graduated Cum Laude with B.S. degree, Fairmont State College, May 1990

Fairmont State College Dean’s List

James A. LaRue Award: Outstanding Senior in Mathematics
Fairmont State College, May 1990
MEMBERSHIPS

Association for Educational Communications and Technology
Virginia Society for Technology in Education
Virginia Tech Instructional Technology Student Association

PEER REVIEWED PUBLICATIONS


Hodges, C.B. (accepted for publication). Lessons learned from a first instructional design experience. *International Journal of Instructional Media*


OTHER PUBLICATIONS


PRESENTATIONS


Stackpole-Hodges, C. L. & Hodges, C. B. (2005, April). *Speech-Language Pathology Students and Online Communities of Professionals*. Instructional Technology Conference, Middle Tennessee State University


Hodges, C. B. (1997, October). *Creating a class homepage*. Department of Mathematics Graduate Student Seminar, Virginia Tech

**ACADEMIC TEACHING EXPERIENCE**

**Virginia Tech Faculty Development Institute**

Basic Statistical Tests with SPSS, Short Course Fall 2005

**Guest Lecture, Virginia Tech**

GRAD 5984: Critically Engaged Teaching with Advanced Technologies, Fall 2004
Conference Workshop

QuickTime virtual reality for web delivery conducted at the Mid-South Instructional Technology Conference Middle Tennessee State University, Murfreesboro TN, April 2002

Math Courses taught at Virginia Tech:

- Linear Algebra -100% online course
- Vector Geometry (*), Calculus I (*), Calculus II (*), Differential Equations (VTel video conferencing system)
- Calculus with Matrices I, Calculus with Matrices II

Math Courses taught at Concord College:


Courses taught at West Virginia University:

- College Algebra (*), Trigonometry, Calculus I, Business Calculus II

(*) Courses contained strong technology components

SERVICE

Service to Department of Mathematics, Virginia Tech:

Chair of Instructor Search Committee, 2005
Member of System Engineer Search Committee, 2004
Member of System Administrator Search Committee, 2004
Member of Undergraduate Program Committee, 2003-2004
Member of Mathematics Assessment Committee, 2002-present
Committee to review Mathematics Computer Services, 1999 - 2000
Math 1206 Goals Committee, 2000
Committee on the Assessment of Non-Traditional Teaching Assignments,
2000-2001
Math Emporium Oversight Committee, 2000 - present
Member of Committee to review mathematics computer services, 1999-2000
Member of Math 2214 Revision Committee, 1998 - 2000
Mathematics Computer Assistance Group Director, 1997 - present
Member of Committee of Instructor Affairs, 1998 – 1999, 2005-2006
Member of Software Evaluation Committee, 1998 - 1999
Member of Instructor Evaluation Committee, 1997 – 1998, 2003-2004
Member of Math 1206 Final Exam Committee, 1998
Member of Math 1205 Final Exam Committee, 1998
Member Departmental Service and Scholarship Committee, 1996 - 1997
Graduate Student Mentor, 1996 - 1998
Member Lower Division Service Committee, 1995 - 1996
Member Registration Committee, 1996 – 1998

Service to Virginia Tech Instructional Technology Student Association

President, May 2005 – present
Co-chair of joint University of Georgia/Virginia Tech committee to organize AECT Graduate Student Lounge at the annual AECT meeting, 2005
Organized fall 2005 picnic
Awards Committee, Spring 2005
Faculty Liaison, Fall 2004
REFERENCES

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Robert F. Olin, Ph.D., Dean of the College of Arts and Sciences, The University of Alabama, Tuscaloosa, AL, 205-348-5972, olin@as.ua.edu

W. Michael Reed, Ed.D., Professor and Director of the Educational Communication and Technology Program, New York University, New York, NY, 212-998-5520, w.michael.reed@nyu.edu

John Rossi, Ph.D., Professor and Head, Department of Mathematics, Virginia Tech, Blacksburg, VA, 540-231-6536, rossij@vt.edu

Michael Williams, Ph.D., Associate Professor and Math Emporium Director, Department of Mathematics, Virginia Tech, Blacksburg, VA, 540-231-9592, williams@vt.edu