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An Assessment Strategy to Mitigate the Effects of Test Anxiety

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Abstract

This paper examines the current literature regarding test anxiety, math anxiety, and general anxiety. Numerous factors that cause anxiety and strategies to mitigate the effects of anxiety are identified. While a comprehensive school-wide or district-wide strategy is recommended, teachers are still able to effectively address anxiety within the classroom. An assessment strategy is then created and presented utilizing the cited literature that can be implemented by teachers of various ages and content areas.

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CHAPTER I: INTRODUCTION

The Importance of Assessments

The importance of assessments in secondary education cannot be overstated. They are the tools stakeholders use to determine a student's knowledge and abilities. At the secondary level, those assessments carry the weight of helping determine a student's grades, college placement, and even career. Secondary math teachers are particularly aware of the importance of assessments. The subject also contributes significantly to the content of college entrance exams. The need for assessments that accurately determine a student's knowledge and abilities is therefore essential.

Colleges, districts, and individual teachers have therefore put forth significant efforts to improve the quality of their assessments. The validity and reliability of assessments have received significant attention and research. Researchers and theorists have broken down validity into smaller components like construct validity, which is ensuring an assessment is actually assessing a construct such as mathematical reasoning or reading comprehension, and criterion validity, which considers how accurately a test determines present or future ability (Miller, 2009, p. 86). These divisions allow individual teachers direction and guidance in evaluating the overall quality of their assessments.

It was during my own study of these two measures of the quality of assessments that I began to seriously investigate my own assessment practices. Overall, I was pleased with the results after analyzing the data I had available. What was present on the tests was covered in class rather proportionately, and all of the content corresponded to the course's learning targets. In other words, the format displayed a high level of validity. Student achievement levels

were rather consistent throughout multiple assessments, indicating sufficient reliability as well. I am not convinced that designing assessments to have high validity and reliability alone are sufficient to ensure quality assessments, however, as other factors can adversely contribute to their quality and merit investigation.

Anxiety as a Factor in Assessments

Anxiety is one factor that can reduce the effectiveness of any assessment and must be accounted for. I experienced anxiety on a math test that adversely affected my grade once unexpectedly in a college course, illustrating to me that anxiety can affect students of any age, even if it is in a subject of strength. Any secondary teacher will be familiar with their own students suffering from similar events. These events can occur regardless of the validity or reliability of an assessment and can therefore alter the otherwise accurate measure an assessment may provide.

Anxiety occurs in many forms that affect students inside the classroom and beyond. Most are familiar with the concept of anxiety, and general anxiety can be defined as “an individual’s disposition toward anxiety about events, behaviors, and competence” (Carey, 2017, p. 2). This form of anxiety transcends the classroom and adolescence. There are also more acute forms of anxiety that are incited by settings or actions that are more relevant and pliable by teachers.

Math anxiety is a well-known form of anxiety in schools and is particularly relevant to my teaching. Reali (2016) defines it as “a state of discomfort associated with performing mathematical tasks” (p. 4). It strongly corresponds with decreased working memory and an increase in computation errors (Bruce, 2016, p. 80). Its prevalence in students is of concern to

teachers as it has long been associated with a decrease in math performance (Hart, 2016, p. 181). Carey (2017) notes it appears across all demographic groups, including age, gender, and socioeconomic status (p. 6).

There are however notable demographic differences in the strength and frequency of math anxiety. Escalera-Chavez (2016) notes that students from higher socioeconomic statuses display higher levels of anxiety (p. 311). Other studies contradict each other regarding gender, with some finding females possessing a higher rate of anxiety (Reali, 2016, p. 2) while others concluding males do (Bruce, 2016, p. 75). Regardless of demographic groups, math anxiety corresponds with decreased working memory and an increase in computation errors (Bruce, 2016, p. 80).

Math anxiety is particularly a secondary level problem. It appears math anxiety may develop from experiences in the classroom, as it is less prevalent at the elementary level (Escalera-Chavez, 2016, p. 311) and then appears in middle school and increases in frequency and severity during high school years (Bruce, 2016, p. 75). This indicates that math anxiety develops throughout a child's education and is influenced by factors potentially within a teacher's control such as assessment practices, or perhaps more influential factors like social pressure.

Just as familiar and impactful to every student and teacher is anxiety which may be caused by assessments. Carey (2017) defines this form of anxiety that affects all ages and subjects as "apprehension in evaluative settings" (p. 1). The term itself can be misleading, as it can occur not only in traditional test settings but any time a student's knowledge or skills are being evaluated. This suggests a simple change in format, such as changing from a traditional

test setting to a problem-based group project, does not itself guarantee a reduction in test anxiety. Like other forms of anxiety, test anxiety has adverse effects on students and those with higher levels of testing anxiety tend to have lower achievement levels (Cassady, 2001, p. 270; Dawood, 2016, p. 57).

While there exists a correlation between math and testing anxieties, the two remain distinct (Carey, 2017, p. 1). The correlation is likely not a coincidence, with Faqe (2016) showing students in the sciences have portrayed higher rates of test anxiety compared to literary students (p. 69). One study concluded that anxiety on math assessments is influenced by test anxiety as much as by math anxiety (Carey, 2017, p. 11). Like math anxiety, test anxiety negatively affects test performance, including high-stakes exams like the SAT (Cassady, 2001, p. 270). Cassady (2001) also notes negative correlations between test anxiety and IQ, aptitude, mechanical knowledge, problem-solving, memory, and grades (p. 273).

Actions and Beliefs Towards Anxiety

Given its recognized adverse effects, there exist several researched methods to determine anxiety levels and how they affect performance. The Modified Abbreviated Math Anxiety Scale (mAMAS), itself a modification of the earlier Abbreviated Method Anxiety Scale, makes the original applicable to all school-aged children and has been found both a valid and reliable assessment tool for math anxiety for all school-aged children (Carey, 2017, p. 1). Carey (2017) posits the Evaluation subscale of the mAMAS is influenced by test anxiety as much as by math anxiety, and that the Learning subscale of the assessment provides a purer measure of math anxiety. The Cognitive Test Anxiety assessment, while also inviting more research, has also proven to be an appropriate measure of test anxiety (Cassady, p. 240). The Revised

Children's Manifest Anxiety Scale (RCMAS) is a reliable and valid means of identifying general anxiety in all school-age children (Lowe, 2015, p. 719). With an understanding of the causes of anxiety, we are better able to reduce it or otherwise mitigate its effects.

The impetus to address test anxiety can come from many sources, including administrators, researchers, parents, students, and of course teachers. Fortunately, the number of schools and districts that are incorporating programs to combat anxiety are on the rise (Maynard, 2017, p. 5). Anxiety is not limited to areas where addressing it is a goal of the school or district, however, so teachers should not be dependent on districts to implement strategies to counter student anxiety, but should be empowered to address it themselves. To do so, teachers should be aware of the causes and effects of anxiety, as well as the numerous strategies developed to combat it.

Suggestions range from utilizing new concepts and technology to traditional recommendations many will be familiar with. Social media, for example, is a new medium of communication that can have demonstrably beneficial academic effects. Deloatch (2017) found a correlation between decreased anxiety levels and simple, encouraging social media messages from friends immediately preceding an assessment. However, this new form of communication can also adversely affect performance, providing students with a convenient means of entertainment at any time, including bedtime. Taveras (2017) identifies numerous academic, emotional, and physical consequences for inadequate sleep among adolescents, for which electronic communication is a leading cause.

Academics also discuss the appropriate time to address anxiety, which can be before or after it affects a student's performance or well-being. Muggeo (2001) found teaching cognitive

strategies largely benefited students who sought out the school nurse due to an acute moment of anxiety (p. 157), while Cohn (1998) suggests teaching cognitive strategies specifically addressing perceived weaknesses and stress inducers to preemptively counter them (p. 514). Alternately, Casado (2012) identified that anxiety could be reduced without cognitive strategies by exposing students to the relevant stimuli to reduce the associated emotional response (p. 10).

While the appropriate time to address anxiety may vary, the occurrence of anxiety is much more predictable, with assessments being one of the best-known and most common forms of anxiety in school. Despite not always being within the teacher's power to change, the format of an assessment can be a source of anxiety. While most secondary teachers recognize the need to prepare students for standardized tests, many have also acknowledged their limitations and have experimented with more authentic tasks as a means of determining students' knowledge and abilities (Rastegaran, 2016, p. 18). Authentic tasks by themselves contribute to learning, and can even increase student performance in multiple-choice assessments (Rastegaran, 2016, p. 18). Their use as assessments, however, presents its own challenges. Seng (2015) determined assessment questions related to real life applications elicited more anxiety than mathematical operations without context (p. 167). Therefore, any attempt by a teacher to increase the authenticity of assessments by utilizing tasks in context must also account for the increase in anxiety these tasks elicit.

While anxiety can exist in many forms, they can all adversely influence a student's performance and therefore an assessment's usefulness. Teachers should have resources available to them to address anxiety autonomously to meet the needs of their students, and

some have a need to do so. Anxiety is an acutely secondary sciences problem, affecting both older students and those in the sciences more than other demographic groups. Investigating the research into anxiety and how to mitigate it are very recent as evidenced by the publication dates of the articles cited thus far. Incorporating strategies that decrease anxiety is an aspect of education that individual teachers have much more control over, certainly more so than the contents of many high-stakes tests. Many of these strategies are supported by research and can be implemented by teachers to reduce anxiety and therefore increase achievement levels.

This thesis will consider the ways in which test anxiety may affect student achievement and how best to mitigate the effects of anxiety in its various forms. Academic literature will be reviewed to determine the causes of anxiety as well as strategies proven to reduce anxiety. Following that, of a comprehensive assessment strategy for secondary teachers that addresses anxiety and its effects on assessments which can be used by teachers of many secondary disciplines will be presented. This strategy will comprise of numerous components, each derived from strategies proven to reduce various forms of anxiety, increase assessment performance, or both. This research will consist entirely of scholarly articles published in academic journals. The system should be comprehensive enough to meet the needs of many academic disciplines and specific enough to address the needs of math teachers in particular.

CHAPTER II: LITERATURE REVIEW

Overview of Literature of Reviewed

Searches of the Educator's Reference Complete and Educator's Reference Information Center (ERIC) were conducted for literature in this thesis. Searches were limited to articles published from 2010 to 2017 unless more general knowledge or theories were employed. Only works published in peer-reviewed journals that focused on education at any level were cited. The keywords used in these searches were "math anxiety causes," "test anxiety causes," "test anxiety strategies, and "student anxiety." The literature review, with the goal of developing a comprehensive strategy to address test anxiety, will be divided into strategies. The first section will comprise teaching strategies to reduce anxiety, including specific teaching goals to more general beliefs about learning. The second section will consist of strategies that should be taught to students to help them understand and reduce their own anxiety levels autonomously. The final section will determine strategies teachers can use in the actual creation of assessments that limit anxiety. This final section will inform the assessment strategy created in Chapter 3. This thesis will consider the ways in which test anxiety may affect student achievement and how best to mitigate the effects of anxiety in its various forms by identifying the causes of anxiety in students and the means proven to reduce it, this thesis aims to synthesize the various strategies into an assessment system that can be employed by secondary teachers.

Teaching Strategies

Teachers can influence students' anxiety levels through a variety of means before an assessment takes place. Much like the assessments themselves, preparation may be the

greatest factor in determining success. Significant and varied action on the part of the teacher should occur before an assessment occurs to best mitigate the adverse effects of anxiety. Student understanding of anxiety, assessment preparation, motivation, and a teacher's own beliefs and their effects on anxiety will be explored in this section.

It should be noted that much of the research cited in this review calls for the implementation of strategies at a school-wide or district-wide level. While a comprehensive strategy that addresses anxiety across all subjects and grade levels is recommended and teachers should certainly encourage their school or district to implement one, the focus of this thesis is what individual teachers are able to do within their own classroom. Fortunately, it should be noted that teacher-led instruction in addressing anxiety such as teaching students how to recognize anxiety and how to minimize its effects was found to be as effective as psychiatrist-led instruction (Collins, 2013, p. 93). This means teachers can be as effective as psychiatrists at a class-wide level and are capable of teaching strategies to mitigate anxiety and should do so regardless of the actions (or inaction) of their district.

Even before taking action, teachers can affect the anxiety levels of students through their own beliefs about learning. Baş (2016) notes these teacher-learning conceptions derive from a teacher's experiences as both a teacher and student and can positively or negatively affect student performance. The traditional mindset views the teacher and textbook as the source of knowledge and the student passively absorbs information. This is diametrically opposed to the constructivist mindset where the student is an active participant in their own learning and the teacher acts as a facilitator (Baş, 2016, p. 210). Many teachers will not be surprised to learn that a constructivist mindset corresponds to higher achievement levels.

The cause of this higher achievement level in constructivist classrooms is multi-faceted. Maralani (2016) concludes that the level of engagement is one of the primary factors in determining a student's achievement level, in large part thanks to reducing test anxiety (p. 44). A constructivist experience in which students are ideally more actively engaged in their own education unsurprisingly leads to more engagement, which corresponds to both higher achievement levels and reduced anxiety levels. That engagement can be broken down into subcomponents so its influence on anxiety can be better understood.

While there are a variety of interpretations, most models conclude that emotions are an important contributor to engagement. A student that is emotionally engaged in the classroom will have a "sense of belonging and relationship with teachers and of the same age friends" (Maralani, 2016, p. 44). A constructivist environment will have students collaborating with peers, and the working towards a common goal can certainly foster that sense of belonging with students. Engaging the teacher in a similar manner, as opposed to being directed by the teacher as an entire class, can also foster that sense of belonging. This sense of belonging in the classroom has multifaceted benefits to student achievement and well-being. Delany (2015) notes that a positive perception of one's learning environment is associated with greater self-efficacy, and higher self-confidence is associated with decreased anxiety.

The complement to a sense of belonging to an engaged student is the ability to be autonomous. In a constructivist environment, the teacher can foster autonomy by giving students a sense of control over their own learning and helping to give students a sense of competency in the task at hand. Conversely, a student with a low sense of confidence can in

fact be distracted during an exam due to this belief, developing text anxiety in the process (Delaney, 2015, p. 1306).

Combined, these traits of engagement help reduce anxiety. Students with their basic psychological needs met have a level of engagement that is negatively correlated to test anxiety (Maralani, 2016, p. 50). It appears an appropriate use of school time, sense of belonging, and confidence in one's ability all help reduce test anxiety by limiting test-irrelevant thinking. Creating student engagement is not limited to the teacher and peers, and factors outside the classroom can also have an effect.

Raufelder (2016) confirms the negative relationship between engagement and test anxiety while also suggesting that the social and academic pressure exerted on students affects their level of engagement. Both short-term and long-term disengagement can impact anxiety levels. Students suffering from anxiety in mathematics, for example, were more likely to avoid math courses in the future (Seng, 2015, p. 162). If anxiety, and not interest or ability, is determining the education and future careers of students, then a greater understanding of how to re-engage students is necessary.

Greater parental involvement is one way to help increase, student engagement in the classroom. Notably, boys reported a greater influence from their fathers compared to girls, with boys perceiving more pressure from fathers and a reduction of test anxiety because of it, whereas girls experienced greater test anxiety from maternal pressure (Raufelder, 2015, p. 3756). Same-sex parents seem to exert greater influence on their child's actions in the classroom, likely because they are gender role models as well. Perhaps this implies that a

teacher is better able to influence a student's anxiety level due to engagement if they are of the same gender as a student, though no study was found which addresses this possibility.

Who is delivering information, be it content or feedback, does have an influence on anxiety levels and is not limited to the parent. Students respond differently depending on who is delivering the message, so teachers should ensure they are not the only ones engaging with students. This agent employed by the teacher supports the student both academically and emotionally, influencing both the cognitive and affective domains of learning simultaneously. Yanghee (2016) found that when lessons were taught through an animated character the anxiety levels among those with already high anxiety levels decreased while overall performance rose. This agent can also be another student, and there are many well-known benefits to having students teach to and learn from each other, though teachers must be vigilant to ensure students are learning the content appropriately.

The greater autonomy granted to students in a constructivist model naturally leads to more opportunities to develop misconceptions or use time poorly, and so adequate planning is still essential for students to develop self-regulatory skills such as metacognition and goal-setting. The Pintrich regulatory model lays out four phases which that can be applied in a constructivist classroom: planning, self-monitoring, control, and evaluation (Montalvo, 2004, p. 4). Other similar models exist which can also be applied, though the importance of incorporating a system that encourages self-regulation is essential in an environment that gives students significant autonomy in their own learning. As noted above, even the perception of inadequate preparation can lead to increased test anxiety.

Though constructivist teaching has numerous benefits and wide support in academia, Baş (2016) notes teaching with a traditional mindset corresponds to lower rates of test anxiety (p. 319). While autonomy in one's learning can certainly increase motivation and meaningfulness, traditional learning environments make students more comfortable with assessments. Teacher-led instruction towards specific outcomes, which very well may be considered discouraging to students, nonetheless provides the explicitness and structure that can be reassuring. An ideal classroom should therefore include the student-driven nature of a constructivist mindset as well as the explicit reinforcement of learning found in a traditional classroom.

Student Strategies

The explicitness often found in traditional classrooms should not be limited to the content but should also extend to strategies that reduce anxiety. To appropriately address test anxiety, students must be made aware of it, including its causes and means to mitigate it. The need to involve students in the process of understanding and addressing their anxiety is highlighted by their inaction without guidance. Faqe (2016) determined very few students employ any strategy to reduce their anxiety levels, and even fewer employed multiple ones. This lack of action often coincides with poor study skills that together make these students poor self-regulators (Faqe, 2016, p. 73). With a majority of students likely to not employ any unprompted action and with a lack of district involvement, it falls to individual teachers to introduce means for students to understand and address their own test anxiety.

Even with preparation anxiety cannot be fully eliminated, nor should it, as a certain degree of anxiety can prove useful. While negative consequences do elicit test anxiety and its

negative effects on performance (Faqe, 2016, p. 70), Dawood (2016) recommends students acknowledge a degree of anxiety is required as a motivating factor for both preparing before and performing during an assessment (p. 63). Indeed, Emmett (2016) notes that intrinsic motivation declines with each advancing year (p. 201) and therefore becomes less reliable and useful as a means of motivation. The goal of a higher achievement level and all its implications can serve as a powerful motivating tool and thus a degree of anxiety is acceptable if appropriately understood by the student.

Fear of consequences is one example of test-irrelevant thinking that can affect student performance during an assessment. Gbore (2016) recommends teachers continuously teach test-wiseness: test-taking strategies meant to reduce anxiety and test-irrelevant thinking during an assessment. These strategies include; preparation before a test, familiarity with types of test items, how to avoid errors during tests, how to use idiosyncrasies built into a test by the teacher, how to use time effectively, and how to eliminate incorrect alternatives. While it may seem ironic that a teacher would address how they created their own assessment, understanding the thoughts behind a test can help students understand why a question was created and how it should be answered. Indeed, thinking like a professional in a content area is often a stated goal of a curriculum.

Focusing on the relevant problem is one of the primary coping skills, along with being emotionally focused and intentionally avoiding the stressor attending to one's emotions about the situation, that is associated with more positive outcomes (Collins, 2014, p. 86). It should never be assumed that students have these skills, and teaching even simple strategies like avoiding a challenging test problem and returning to it later can reduce anxiety and increase

performance. The importance of developing coping skills cannot be overstated as they transcend performance on an assessment and affect many areas of an individual's life. Collins (2014) highlights the importance of addressing anxiety by stating that without intervention, "even children with high, although not clinically significant, levels of anxiety can become adults whose anxiety impedes the growth of satisfactory family and work relationships" (p. 86).

While focusing on the relevant problem, students should also be taught how to approach that problem in a variety of ways. Ulu (2017) notes that in mathematics for example, students with low problem-solving abilities often begin writing mathematical statements without planning, and thus often perform subsequent actions that are irrelevant to the task at hand (p. 58). More successful students alternately employ strategies that simplify the task into smaller, more understandable components. Teaching a subject, and test-taking, through the lens of problem-solving will thus help students be more prepared for an assessment and thus undergo less anxiety.

Students should also be taught explicitly about the nature and causes of anxiety. While some students may be more prone to general anxiety than others, anxiety is a learned phenomenon based on negative cognitive and affective reactions (Sharma, 2016, p. 509). Reali (2016) confirms this by finding that anxiety within a content area rises with grade level. This means a student suffering from anxiety in a class arrived in that class with a level of anxiety towards being assessed in that content area, and that anxiety was reinforced in the previous years. With the knowledge that anxiety is a learned behavior, students can then begin incorporating strategies that mitigate it.

Many of these strategies can be included under the umbrella of resilience. Delany (2015) defines resilience as an "adaptive stress resistant personal quality that permits one to thrive despite adversity" and affects both the individual practices of the students as well as the professional practices of teachers (p. 1306). Stress over things outside of one's control and poor self-efficacy, are common causes of anxiety and so must be addressed. Delany (2015) found a combination of cognitive behavior technique, strengths-based positive psychology, and goal-oriented performance psychology to be effective in reducing anxiety levels of students.

Bruce (2016) recommends the implementation of anxiety hierarchy technique as a component of cognitive behavior therapy to reduce anxiety levels (p. 75) and defines it broadly as both learned behaviors and how one's environment influences those behaviors. While a teacher has less expertise and resources compared to a professional behavior therapist, teachers are at times able to identify and address behaviors and their environmental triggers in students and should do so when possible. The anxiety hierarchy technique involves regular exposure to stimuli that trigger anxiety, beginning with weaker stimuli, practicing breathing and calming techniques until they are ready to progress to more anxiety-inducing stimuli.

A greater understanding of anxiety can also aid students in identifying symptoms that require addressing. Physical symptoms of anxiety such as drowsiness, dizziness, and headaches often appear when anxiety-inducing content is presented (Seng, 2015, p. 162), and, along with perspiration and increased heart rate, are among the subjective criteria students employ to identify their anxiety levels, though they are not alone accurate predictors of anxiety levels, and by extension, achievement. Cassady (2001) discovered that emotional responses to anxiety are also associated with declining performance when worry is also present (p. 271).

In other words, the cognitive domain is much more influential regarding the adverse effects of anxiety. Cognitive test anxiety is most often identified through comparisons with peers, considering consequences of poor performance, low levels of confidence, unpreparedness, self-worth, and disappointing parents, and are better predictors in declining performance (Cassady, 2001, p. 272). By becoming more aware of the thoughts that lead to predictable drops in achievement and developing the ability to suppress them during assessments in favor of thoughts relevant to the assessment, students will have a greater ability to reduce their anxiety levels.

While the cognitive behavioral technique can be used to limit negative effects like anxiety, it can also be used to promote positive outcomes as well. By utilizing their strengths, individuals can develop a personal model of resilience which can be applied to numerous instances of adversity or anxiety, and not just limited to testing situations. Padesky (2012) defines strengths as the "strategies, beliefs, and personal assets used with relative ease that can promote the positive quality one is trying to build" (p. 284). By understanding their own strengths, an individual can create this personal model of resilience that is more effective than a more general one recommended to everyone regardless of their strengths and areas of need. This model can then be autonomously applied in the future if relapses in anxiety levels occur.

Of course, teachers should provide guidance and help students understand their strengths and develop this model. After all, to understand one's strengths, students need to recognize how and where they learn best, and so they will need time in the classroom to develop this model in addition to learning the content. An ideal learning environment allows students "to monitor their beliefs and trial and refine strategies to positively change unhelpful

responses" (Delany, 2015, p. 1309). Fortunately, a constructivist learning environment already encourages significant time in class for students to develop an understanding of class material, and that time can be used to identifying strengths and creating a model of resilience as well.

Goal-oriented performance psychology is the third component of resilience training. Like the use of strengths as described above, it de-emphasizes weaknesses and emphasizes what is desired and possible. As Delany notes, goal-oriented performance psychology focuses on "what the students want rather than what they [don't] have" (p. 1307). From a larger perspective, this focus on the goal, or the task at hand, is analogous to the avoidance of test-irrelevant thinking during test taking.

The goals themselves should also include the development of resilience in addition to content-related ones. Students and teachers should both set and work towards this goal. Delany (2015) recommends transformative change as a desired learning outcome and argues it "resonates with educational goals related to developing professional identities, and attributes of agency and lifelong learning" (p. 1319). Resilience training, then, not only prepares students for a teacher's assessments but for all circumstances of adversity in a student's life. Further, it is a gradual shift from organization and support from the teacher to the strengths and capacities of autonomous students.

Assessment Strategies

In addition to the numerous teaching and learning strategies used to combat anxiety, teachers can implicitly reduce anxiety through assessments. Assessments are naturally a frequent cause of anxiety. In fact, it is the primary focus of this thesis, but they can also be used

a means of reducing that anxiety as well. From feedback to format, there exist numerous other research-based strategies to reduce anxieties as they relate to assessment performance.

The fear of making a mistake is perhaps a student's most obvious concern during an assessment, but, while mistakes cannot be completely avoided, Aksu (2016) notes that appropriate use of these errors in teaching can have both cognitive and affective benefits to the students (p. 66). Along with self-efficacy, mistake-handling learning awareness explains a significant portion of math anxiety (Aksu, 2016, p. 68). Fortunately for teachers, this can be addressed through modeling the desired behavior or through feedback to individual students. One such way to cultivate a positive emotional response to mistakes and the subsequent corrections is to award bonus points to students that correct teacher mistakes. Not only does this eliminate the stigma of mistake-making by acknowledging (and celebrating) those made by a teacher, it also encourages attention with the extrinsic reward of bonus points.

Mok (2016) claims that summary writing, while generally inferior to testing, is not affected by test anxiety and is a possible assessment alternative for students with high levels of test anxiety (p. 578). Gbore (2016) concludes that test-taking strategies significantly reduce test anxiety and recommends incorporating test-taking strategies into both secondary curricula and teacher training programs (Gbore, 2016, p. 38). Maralani (2016) agrees with numerous other studies that students with involved parents and those who have their basic psychological needs met portray lower levels of test anxiety and higher performance (Maralani, 2016, p. 30). The situated learning model utilizing stories, reflection, cognitive apprenticeship, collaboration, coaching, multiple practices, articulation of learning skills, and technology also significantly decreases math anxiety (Sharma, 2016, p. 511). Real-life applications in assessments also elicit

greater levels of test anxiety than numerical calculations (Seng, 2015, p. 167), meaning additional preparations are required to avoid these questions reducing an assessment's validity through increased anxiety.

This suggests repeated exposure to the content and assessments could reduce test anxiety levels. Indeed, low self-confidence for specific tasks and awareness of being unprepared are among the most common situation factors that elicit test anxiety (Cassady, 2001, p. 274). By regularly exposing students to the same content through multiple assessments, students will simultaneously be more prepared for specific tasks and more familiar with the assessment format. Further, any success for any individual task will raise self-confidence levels for future iterations of that task on later assessments.

A regular and frequent schedule will also encourage students to develop proper study habits. Faqe (2016) emphasizes the importance of this practice in their own findings by concluding preparation, a fixed study time, and practice are "the best steps to reduce test anxiety" (p. 74). Though as students are unlikely to understand or undertake such practices autonomously, this should be taught in addition to the content. Teachers should model this behavior through their teaching, and a regular system of review embedded in the structure of the class will allow students and teachers to regularly review content and assess understanding.

This repetition of content has other cognitive effects that benefit learning and retention in addition to reducing anxiety. The acquisition of a new understanding or performing a new skill often involves new connections being formed in the brain; the cells of the brain, called neurons, connecting to each other through newly-formed axons. When not used, these axons can weaken or disappear entirely, manifesting in a loss of knowledge or abilities. The regular

use of this connection, however, causes the axon to become coated with myelin, a fatty substance that preserves and strengthens the connection.

This myelin coating over axons is very important to their effectiveness and longevity. Duncan (2017) determined that once coated, myelin sheaths can preserve an axon's function from several years to a lifetime (p. E9865), further emphasizing the need for their repeated use. Myelin is an electric insulator, and axons coated in myelin transmit signals faster and with less required energy that uncoated axons (Brady, 2012, p. 181), making them more effective. The development of a myelin coating from regular use is most likely to occur over the course of multiple days or even weeks (Almeida, 2017, p. 10023). This means a single day of study, no matter how intensive or time consuming, is unlikely to aid in long-term retention, something to warn all students who procrastinate before an assessment. As the axon strengthens, not only do tasks become more routine and less anxiety-inducing, but thinking becomes faster, more coordinated, and complex (Kuther, 2016, p. 7). The regular performance of a task not only increases fluency in the task itself but also aids in a better understanding of that task while permitting higher-level actions related to that task. Students are better able to utilize knowledge and skills in the future if they are regularly assessed and reviewed.

Any perceived reduction in anxiety and development of regular study habits due to this system can then be applied to concurrent and future courses of study autonomous of the teacher. It should be made explicit that if a system of study that involves regular and repeated practice reduces anxiety in a classroom that requires it, that same system will likely have the same effect when other systems of assessment are used. University courses are known to employ less frequent and more influential assessments, and an appropriate system of

autonomous study is an important tool in preparing for them. Many students enter college academically unprepared (Herman, 2017, p. 1), and the development of proper study habits, and the associated decrease in anxiety, is a skill that will serve them for years into the future.

In support of this aim, the format of assessments should be designed to minimize anxiety. Faqe (2016) states that, in addition to making an organized study schedule, students "should familiarize themselves with the format of the questions" (p. 73). If the teacher is the one designing an assessment, it is their responsibility to inform the students of the format so the format itself does not adversely affect their performance. Writing exam questions that are clear, concise, and best limit sources of confusion is a topic on which many teachers receive no training, and so teachers may wish to use externally developed assessments or questions to avoid personally erring through an assessment. Assessments are a demonstration of present knowledge and skills and should not include any task with which the student is unprepared to address. By utilizing phrasing and contexts with which the student is familiar, the teacher is reducing a common cause of test anxiety.

The perceived threat, or fear of negative consequences, posed by an exam is the other most common situation factor that must be addressed, as noted by Cassady (2001, p. 274). There are a variety of reasons a student's achievement level on an assessment does not correspond to their actual knowledge or ability level. This could be due to a poor level of reliability in the assessment itself or any number of other factors such as inadequate sleep or other sources of stress. In other words, there are factors that can adversely affect achievement levels that may be beyond a student's control. Since students without a sense of control feel more anxiety, the fear of consequences from poor performance can compound anxiety levels.

Whenever possible, assessments should have a limited degree of finality: either a means of correction or some ability to influence an achievement level.

Even with the consequences reduced and the content of an assessment determined, the organization of that content can also affect anxiety levels. Khan (2010) observed that student performance decreased for all tasks after anxiety levels were incited. In other words, once anxiety levels rise, all following student performance decreases regardless of content (p. 206). Assessments should be organized with content least likely to induce anxiety at the beginning, followed by successively more challenging material. This concept should be familiar to many teachers, as a traditional exam may begin with multiple-choice questions which pose less challenge than the short answer or essay questions that appear later.

Since the perception of poor preparation is another common cause of test anxiety, formative assessments provide a means to reduce it. A formative assessment of the same format as the actual assessment helps students understand exactly how they will be assessed, as well as making explicit the knowledge or skills they will need to demonstrate. These can even be mock graded to further this understanding. MacLellan (2001) however notes that students rarely use assessment results to improve their learning nor view feedback as helpful, believing criteria provided in the feedback is unclear. This indicates that formative assessments should align closely in content and format to summative assessments so that the connection is more explicit. Numerous recurrences of this pattern can further this goal.

The complement to formative assessments is the feedback given back to students. After all, formative assessments have no purpose if they do not provide the opportunity for a student to change their behavior and increase their abilities. Carless (2006) notes that many students

are dissatisfied with the feedback they do receive, citing its lack of specific advice, unclear meaning, and have a negative impact on self-perception and confidence (p. 200). This means that, if given improperly, feedback can not only have little to no positive impact on the cognitive domain of learning but adversely impact the affective domain as well.

To be effective, feedback must first "provide information specifically relating to the task or process of learning that fills a gap between what is understood and what is aimed to be understood" (Hattie, 2007, p. 82). In addition to acknowledging successes, correcting deficiencies before an assessment is a primary goal of feedback, so that feedback should have a positive impact on later achievement levels. It follows that this feedback should occur as frequently as possible to make up these discrepancies as soon as possible to mitigate future misunderstandings or difficulties and allow for future feedback prior to an assessment.

Since students with a sense of belonging and control over their learning exhibit lower levels of test anxiety, the development of self-regulatory behavior should also be a long-term goal of feedback. Self-regulatory behavior can be divided into two components: self-appraisal, in which students evaluate their own knowledge and abilities, and self-management, where they plan, correct mistakes, and initiate correcting strategies (Hattie, 2007, p. 94).Regarding assessments, Hattie (2007) recommends they not only inform teachers and students about the task and the strategies to understand it, but encourage "regulation, engagement, and confidence" (p. 101) as well. Feedback should therefore not only provide information regarding the task but beyond that "to regulation about continuing beyond the task to more challenging tasks and goals" (p. 102). Feedback, then, should not only address any mistakes but also guide students to greater tasks and greater autonomy.

Control over one's learning is both a motivator and a reducer of anxiety, and giving students more control over how they will be assessed is another tool available to teachers. Providing students with a degree of choice in their assessments is a reasonable, initial source of flexibility without being too disruptive to teachers' and students' current perceptions of assessments. Irwin (2012) describes student choice in assessments as "a first step towards a more student-led pedagogy, while increasing student engagement in the assessment process and setting criteria" (p. 782). While students and indeed many teachers may not be ready for student control over learning and assessing, providing them a choice among teacher-created or teacher-approved assessments is indeed an initial step in this direction.

Flexibility is by nature open-ended, and there are a variety of ways for teachers to allow student choice in an assessment. These methods of student choice can include determining the weighting of assessment tasks or the tasks themselves, as well as equivalent means of demonstrating learning outcomes (Irwin, 2012, p. 774). More flexibility also increases the odds are misunderstandings, discrepancies, and of course increased levels of anxiety occurring. It is therefore recommended that teachers introduce student choice in a limited, controlled fashion to ensure a positive experience.

It can be difficult for teachers to incorporate anxiety-assessing strategies consistently in their teaching, and so incorporating them into their assessments can help. Indeed, with so many factors requiring the attention of the class and the teacher, a system should be put in place that ensures anxiety is addressed even when it is not consciously a priority. By tying that system to assessments, that system can continue to address anxiety implicitly long after a single, explicit lesson regarding anxiety occurs.

Combined, these findings presented above help teachers understand the causes of anxiety, the effects it has on student performance, and how best to mitigate them. Anxiety has many causes, including past experiences, fear of consequences, and lack of confidence and exist at all age levels and content areas. Fortunately, teachers are able to aid students in mitigating the effects of anxiety by teaching strategies and altering their own beliefs, teaching practices, and assessment methods.

Implementing assessment methods is a particularly useful means of reducing student anxiety. While teaching coping strategies and appropriate study habits to students can certainly be effective, they require classroom time, perhaps throughout the year. Once assessment strategies are in place, however, they ensure the practices that reduce anxiety embedded within them continue to be utilized even if they are not a point of emphasis in the classroom. Assessment strategies are therefore an ideal means of developing appropriate study habits in students.

CHAPTER III: APPLICATION OF THE RESEARCH

Assessment Format

With the importance of regular study habits established, it falls to the teacher to develop those habits in their students. With grades remaining an important source of extrinsic motivation, those habits can be developed through an appropriate use of assessments. If students are assessed multiple times at an expected frequency, a system of study can emerge. The repeated act of preparing for, say, a *single* weekly assessment can naturally develop into a *system* of weekly review and study of learned material. If this assessment system repeats content, this systematic review will also involve the review of content multiple times. If a student has an assessment on a specific day of the week each week, they should develop the regular study habits which are an important indicator of success in preparation for it.

With the frequency of assessments determined, the content should also be employed in a way that minimizes anxiety. An assessment with questions identical to those of homework questions or those otherwise done in class will ensure students are adequately prepared. Writing understandable directions that minimize the possibility for confusion can be challenging for anyone considering the numerous pitfalls that can affect performance (Haladyana, 1989, p. 40), and thus utilizing the question format provided from homework significantly reduces the risk of a teacher's writing impacting student performance. Assessments should be a documentation of present knowledge and abilities and should never possess new information, and using the phrasing and format with which students are familiar helps reinforce that fact.

To further address the fear instilled by the threat of an assessment, a system of assessment where content is assessed multiple times offers a convenient solution. Assessing

concept multiple times creates a sampling of student work that allows a teacher to differentiate gaps in knowledge or ability (i.e., repeated errors on multiple assessments) from a statistical outlier (i.e., an error that is not repeated) which may not provide an accurate assessment of a student's abilities. This differentiation is more difficult if a concept and any associated errors appear only once.

These statistical outliers, those that do not indicate a student's actual abilities, should not influence a student's achievement levels. The existence of multiple assessments of a given concept allows a teacher to discard one or more of the lowest scoring assessments while still possessing a sample on which to determine a student's achievement level. With the knowledge that any given assessment may not adversely affect their grade, the perceived threat that assessment poses, and the associated anxiety level that accompanies that threat, diminishes.

The content of these assessments should also be organized in a way that minimizes anxiety. A system of regular assessment should begin with the oldest, most familiar content followed by newer and newer content. Heightened anxiety levels remain risen, and so if a task causes anxiety, that anxiety will remain and adversely affect student performance on the following tasks, even if those tasks themselves are not stressful to the student. The content students are most familiar with, the oldest content, should appear first. More recent content which is less familiar to the students and more likely to elicit anxiety should follow. Any anxiety caused by that later content cannot adversely affect achievement on the earlier, completed content.

The recursive nature of these assessments also helps students adequately prepare for subsequent exams, further reducing anxiety. If these weekly assessments contain material from

previous weeks, then each assessment informs students of their current knowledge and abilities in content that will be assessed the following week. For example, these weekly assessments each have five sections representing the previous five weeks of course material, the student will have four opportunities to review their performance and demonstrate understanding after a concept is initially assessed. Students can use previous results to reflect upon their perception of their abilities and compare them to their actual performance. Study habits can be reviewed weekly, allowing students to refine those study habits and their understanding of their abilities.

Accompanying the student's review of achievement levels and preparation for future assessments is the feedback given to students by the teacher. While feedback should occur regularly in the learning process and certainly before any assessments, the attachment of feedback to assessments, and in particular to content that will appear on assessments in the very near future, can naturally be very effective considering the lack of feedback and follow-up are key problems in assessments (Cassady, 2006, p. 224). Higher achievement scores are an obvious source of external motivation to receive and act upon feedback. In addition to better grades, feedback should have the more long-term goal of cultivating self-regulatory habits and high self-efficacy (Hattie, 2007, p. 102). By incorporating this assessment strategy with a constructivist learning environment, the teacher will have more time in which to engage with individual students and provide feedback with these goals in mind.

Teachers can further student control over their learning by giving them a degree of choice in these assessments. Note how this system of assessment only states that a given week's content is assessed multiple times. The teacher is free to determine how that content

appears, and by extension, so is the student depending on the amount of choice offered by the teacher. Teachers could allow a student to demonstrate their understanding of a concept by asking them to complete their choice of one of several tasks. For example, an assessment could contain several scenarios involving a concept, from which the students would choose which to perform.

Application to Different Learning Models

Far from being its own educational model, this system of spiraling assessments synthesizes well with a variety of learning models. Therefore, this approach can often be adopted by teachers to enhance the learning and assessment within an existing system. Teachers are naturally constrained by the practices and requirements of their district, and so this model can be manipulated to fit the needs of the teacher and students as well as the district.

The spiral testing system can be easily incorporated into a traditional assessment model. A traditional system is where a student receives a letter grade for a unit or class determined by a percentage score on assessments and possibly other factors like homework and attendance. The spiral testing model naturally informs only the assessment portion of the grade, but instead of a single assessment determining an achievement level for a concept, that content is assessed multiple times, providing a larger sample from which to determine the achievement level.

Perhaps more importantly, however, is the feedback provided by an assessment which informs later assessments. If an assessment provides both a measure of current knowledge or abilities and feedback to a student prior to another assessment, that assessment becomes both formative and summative. Formative assessments, for example homework or discussions with

students, are often informal and even ungraded. Students then receive feedback based on the teacher's observations before an assessment. Summative assessments typically occur at the end of a term and measure a student's knowledge and abilities without the possibility of correction, either in student understanding or achievement level. The spiral testing model combines the two: continuously informing the student and teacher of present abilities while providing the opportunity to demonstrate those abilities on future assessments.

Providing multiple opportunities to demonstrate understanding is a fundamental principle of mastery learning, an alternate model of instruction that is becoming increasingly popular. In the master learning model as initially designed by Benjamin Bloom, teachers administer a formative assessment after a week or two of instructional time. That formative assessment is followed by feedback specific to the needs of the student and the students receive "a second, parallel formative assessment that addresses the same learning goals of the unit but includes somewhat different problems, questions, or prompts," which "serves as a powerful motivational tool by offering students a second chance to succeed" (Guskey, 2010, p. 52). The model proposed here in fact offers them five chances to demonstrate understanding or ability. Should teachers deem it appropriate, they could also allow students to test out of content, meaning the only repeated sections are those in which they did not demonstrate mastery. This would be particularly useful in content areas other than mathematics where knowledge or a skill may not be required for later content.

In summary, the mastery learning system of instruction, progress monitoring through regular formative assessments, corrective feedback later, and then parallel formative assessments coincides well with this spiral testing system. The spiral system, however, overlaps

units so that multiple concepts are assessed simultaneously. It should be noted that a mastery learning system may only require a student to demonstrate mastery of a concept once, and so this spiral testing method can be used in a way that grades on understanding and not as a percentage as needed by the teacher.

The model also complements the constructivist theory of learning quite well. Recall Pintrich's model of self-regulation that asks students to plan, self-monitor, control, and evaluate their behavior regularly (Pintrich, 2000, p. 547). The weekly assessments provide a framework for students to apply those four steps and analyze the results. With content being repeated numerous times, students can set specific goals, diagnose the effects of their efforts, and alter or refine their study habits as needed.

The spiral testing model can be adopted into other educational systems that have their own assessment systems, including the International Baccalaureate which has an external component for evaluation. Whether the spiral model is used for grading or not, it can still be used to regularly reinforce learning and diagnose areas of need before summative assessments. Indeed, one of the twenty-first-century skills espoused by the International Baccalaureate is "the self-discipline and organization needed to manage one's own work" (Hill, 2014, p. 47). The spiral system can be incorporated to model such behavior and develop those skills.

The Model Exemplified

While acknowledging this model can be altered to meet the needs of different subjects, age groups, and districts, it will be presented and exemplified as described in the previous section. Figure 3.1 below shows a template of seven weeks of assessments, beginning with Week 5. Within each test there are five sections, each comprising the previous five weeks of

course material. The new section or sections covered in a given week appear at the bottom of a column and they appear at the end of that week's assessment, with the previous four weeks of material appearing before it in chronological order. The newest section of Week 5's assessment, for example, represents the material from the fifth week of class. Highlighted in blue, note how it appears and "spirals up" through the subsequent four assessments, providing weekly opportunities to reflect upon a student's demonstrated abilities, implement changes or further practice, and be assessed by the teacher and student.

Figure 3.1. Weekly Assessment Format

Section	Week 5	6	7	8	9	10	11
A	1	2	3	4	5	6	7
B	2	3	4	5	6	7	8
C	3	4	5	6	7	8	9
D	4	5	6	7	8	9	10
E	5	6	7	8	9	10	11

Figure 3.1. Example of seven consecutive weeks of assessment. Each assessment is composed of five sections corresponding the previous five weeks' material. The fifth week's content is highlighted in blue.

In any given class, a week's content should be easily identifiable to the student so it will be clear on what content they will be assessed and should be presented in a manner deemed appropriate for the course. Figure 3.2 shows the same seven weeks of content for a high school geometry class. The last cell for week five, for example, reads "2.1/2.2," meaning Section 1 and Section 2 of the second chapter were covered that week. Those sections appear in the fourth cell of week six, the third cell in week seven, the second cell in week eight, and the first cell in week 9, meaning it will be assessed for a total of five consecutive weeks.

Figure 3.2. Assessment Format with Content Identified

Section	Week 5	6	7	8	9	10	11
A	1.4	1.5	1.6/1.7	1.8/1.9	2.1/2.2	2.5/2.6	2.6/2.7
B	1.5	1.6/1.7	1.8/1.9	2.1/2.2	2.5/2.6	2.6/2.7	3.2/3.3
C	1.6/1.7	1.8/1.9	2.1/2.2	2.5/2.6	2.6/2.7	3.2/3.3	3.4/3.5
D	1.8/1.9	2.1/2.2	2.5/2.6	2.6/2.7	3.2/3.3	3.4/3.5	3.6
E	2.1/2.2	2.5/2.6	2.6/2.7	3.2/3.3	3.4/3.5	3.6	4.1

Figure 3.2. Example of seven consecutive assessments. Each week concludes with a test with five sections corresponding to the previous five weeks of material. The numbers in each cell refer to the chapter and sections covered during that week. The colors visually differentiate chapters.

While the content is repeated and the format remains the same, the questions themselves vary to ensure the students are demonstrating mastery of the concept and the memorization of the same problem. One of the desired outcomes from Week 4's lessons is to write the converse, inverse, and contrapositive of a given conditional statement, then find the truth value. That statement and the accompanying truth values should vary from each week. Examples of conditional statements that can be used to assess this concept are below, while further examples can be found in the three complete Geometry tests that appear in Appendix A, Appendix B, and Appendix C.

- If 2 segments have the same length, then they are congruent.
- If two angles form a linear pair, then they are supplementary.
- If $x = 5$, then $x^2 = 25$.

- If an animal is a moose, then the animal is a mammal.

In this course, the essential outcomes are closely tied to the content of the various sections of the textbook, and so each week's content is identified by the appropriate section of the book. This course is divided into ten units, each of which is assessed independently of each other. To clearly differentiate how unit grades are determined, each unit is distinguished by color. This is one example of how a teacher can visually organize this system to meet the needs of their students.

Student performance should also be presented in a manner that aids student reflection and planning. Just as useful as knowing the content on which they will be assessed is knowing their previous performance on that content. Figure 3.3 illustrates a student's achievement levels through the schedule that appears above. With each section being worth a maximum of twenty points, this student should realize their performance in the last two sections of Week 5's assessment is lower than the earlier ones and should devote time studying those sections in addition to the new content that will appear on the next exam. Students are thus confronted with objective measures of their own abilities and can reflect weekly upon their performance and set goals and actions for improvement.

Figure 3.3. Assessment Format with Grades

Section	Week 5	6	7	8	9	10	11
A	20	16	20	17	19	20	18
B	16	17	18	20	17	19	19
C	15	18	18	20	16	20	16
D	14	17	19	16	20	16	20
E	14	20	8	20	13	15	16

Figure 3-3. Example of student performance for the fifth through eleventh weeks' assessments. All scores are out of a maximum of 20 points, and each section contributes to one of the ten separately graded units as noted by color.

There is no special training a teacher would require to utilize this assessment system. In fact, it can greatly simplify the process of creating assessments by establishing the content and format of an assessment. In mathematics, for example, questions can be identical except for different numbers, as shown in the example tests in Appendices A, B, and C. It follows that 80% of any test is already determined as only the newest 20% is not repeated from the previous one. This is particularly useful for teachers who are required to create their own assessments and are not fully comfortable with the process.

Regardless of how an individual teacher chooses to implement and present this assessment strategy with students, the core principles of reducing anxiety through repetition, reflection, planning, and explicitness of content and format remain. While this strategy itself does not comprehensively address anxiety without explicit instruction regarding anxiety, teacher strategies, and feedback, it does provide a framework that implicitly directs students towards practices that reduce anxiety, such as regular study habits, reflection, and an understanding of what must be demonstrated.

CHAPTER IV: DISCUSSION AND CONCLUSION

Summary

Assessments are the predominant tool for determining a student's knowledge and skills, and so the need for them to be reliable and valid is of particular importance to secondary educators where the stakes for students are the highest. Mitigating factors such as anxiety in its various forms could be as damaging to the results as flaws in the test itself and must be addressed (Gbore, 2016, p. 34). The adverse effects of these factors can extend beyond the classroom into university acceptance and occupation placement. Numerous research-based strategies exist that have demonstrably reduced anxiety and improved student performance.

Many schools and districts lack explicit strategies to address anxiety, though individual teachers can incorporate strategies that reduce test anxiety as part of their curriculum to improve the validity of their assessments. Indeed, with their daily interaction with students and their awareness of their individual needs, teachers are often the ideal method of delivery for anxiety-reducing strategies (Collins, 2014, p. 95). Many of the strategies discussed in this thesis require explicitness and time that may be needed for course content or other needs. The assessment system developed here is thus presented as a means of incorporating many of these anxiety-addressing strategies while minimizing the time and effort to implement them throughout the school year.

In addition to addressing anxiety through strategies like explicitness with assessed content, familiarity with the testing format, and developing regular study habits, it has other benefits as well. This strategy can be incorporated into various content areas and assessment systems like the IB and has many traits that synthesize well with the constructivist theory of

learning and Bloom's mastery learning, such as numerous formative assessments and multiple chances to succeed (Guskey, 2010, 52). The system also aids in the reliability and validity of assessments. The assessment of content multiple times allows for a greater sampling from which to gauge understanding, while the equal division of assessments by week helps ensure that a concept's influence on a student's grade is proportional to the amount of time spent on that concept.

Professional Application

Education is in many ways focused on the results: educators have certain expected outcomes for an individual class and their exit into adulthood. How students arrive at those outcomes is less certain, as the means to reach them can and should differ as determined by the needs, interests, and abilities of individual students. To document students' achievements against these outcomes, numerous strategies have been implemented throughout the United States and the wider world.

The International Baccalaureate (IB) was developed from the need of universally accepted outcomes for an increasingly globalized world. With the number of students studying in areas or even countries other than the place of their birth increasing, the appeal and popularity of the IB and its external assessments have similarly increased (Doherty, 2009, p. 73). While those external assessments and desired outcomes are not negotiable, the teacher does have significant autonomy by which to meet them. Ideally, the teacher should implement strategies that encourage autonomy, regulation, reflection, and collaboration: the twenty-first century skills targeted by the IB which can be developed through this spiral testing strategy.

The desire for specific exit outcomes necessary for future success has also taken hold in America. The Common Core State Standards (CCSS) initiative aimed to have "the states adopt uniformly high standards for college and career readiness," including desired outcomes in English Language Arts and Mathematics at the end of each grade level (Lee, 2017, p. 3). Lee (2017) also emphasizes that the CCSS initiative differs from previous reform movements in that it emphasizes student outcomes over teacher and curriculum changes. Teaching practices should similarly reflect this shift, with those practices aimed to help all students reach those desired outcomes.

The CCSS is not without controversy, and some states have not implemented the standards. This is not necessarily a rejection of the goals of the CCSS, however. Minnesota, for example, did not implement the Common Core Mathematics standards because it was felt their standards were even higher. Using the same vocabulary as the CCSS, then-Education Commissioner Brenda Cassellius argued their standards already aimed for students to be "college and career ready," while having "the focus be on mastery" (Weber, 2012). Regardless of a state's or district's stance regarding the Common Core, there is a national emphasis placed on the desired outcomes of students, and so all teachers should implement practices with those outcomes in mind.

The focus on mastery is similarly a common theme throughout education reform today. Whether it is a focus of state standards like Minnesota or it is the defining feature like the eponymous mastery learning originally championed by Bloom, student mastery is being emphasized in education nationally. Once again, if the focus is on the students reaching certain outcomes, teaching strategies should similarly focus on the students. Those strategies should

help students develop practices that not only lead to success in mastering content but "sustain and extend" (Guskey, 2010, p. 57) that success into college and careers.

We can only document the mastery of these outcomes with valid and reliable assessments, however, and anxiety is a significant factor that can affect the accuracy of a student's assessment. Test anxiety is a recognized problem from primary school to university and all over the globe as evidenced by the works referenced in this thesis. And while it is recognized, the implementation of strategies to address it remains sporadic and un-unified. In fact, neither the IB, the CCSS, the Minnesota state standards for Mathematics, nor mastery learning as defined by Bloom make any reference to anxiety, its effects, or how to address it.

In the absence of any emphasis or requirements dictated from above, it falls to the teacher to minimize the adverse effects of anxiety. While teachers may not have any training regarding test anxiety, they can be nonetheless effective in addressing it. With so many areas of concern in a classroom, it behooves teachers to implement a system with anxiety-combating strategies embedded within it so that anxiety is still being addressed even when it is not a conscious point of emphasis. A spiraling testing strategy is one such example where students are provided the framework to develop regular habits of study and reflection with an explicit understanding of how they will be assessed, all of which correspond to lower anxiety levels.

Limitations of the Research

It should be noted the author of this thesis believed in the effectiveness of the spiral assessment method because he uses it himself, and it was a concept pioneered by his own father. Those are two very large concerns regarding impartiality, which is why the author began scrutinizing this method initially. Any results from the author should therefore be scrutinized as

the findings of someone who found what they wanted to find, as a strong possibility of bias exists.

Still, this testing method as described does appear to address many of the common sources of testing anxiety, though to what degree has not been determined. It is also a model that can be implemented by individual teachers in place of a school- or district-wide effort to mitigate anxiety's effects. The lack of any comprehensive effort to combat anxiety has been both a struggle in researching this thesis while driving it towards a model which teachers can implement autonomously.

Many of the strategies that do exist also require a significant amount of time and resources that cannot be guaranteed by many schools and over extended periods of time. Some schools lack the personnel like school psychiatrists to aid students in recognizing and coping with symptoms, while many teachers lack the class time to implement strategies in addition to the myriad other points of emphasis. These findings drove the solution to one where strategies were implicit in the learning and assessment format and minimized the time and effort to continuously emphasize them.

Implications for Future Research

Indeed, the long-term effectiveness of many of these strategies remains in question. None of the research cited in this thesis is longitudinal, and so the effectiveness of the strategies after they are immediately taught and assessed is unknown. It is recommended that long-term studies be done for these existing strategies to determine their long-term effectiveness in different classes and contexts.

The effectiveness of these strategies may also be enhanced when they are retaught. To what extent will students autonomously employ a given strategy after it has been taught? Will reteaching that strategy over a certain period increase that likelihood, and it will it increase the likelihood of them employing it in different contexts? With limited time in a classroom, it would greatly benefit teachers to know the optimal time to devote to a particular strategy.

Teacher attitudes and the structure of the class are also within a teacher's power to change, but will relevant changes correspond to appropriately decreased levels of anxiety? This thesis links numerous teaching strategies like repetition of content and a behaviorist learning environment to a reduction in the frequency and strength of anxiety, but further studies quantifying this relationship are recommended.

Similarly, entire learning systems may affect anxiety. Can a mastery learning system itself be an effective means of reducing anxiety? What effect does the IB have on anxiety levels? Perhaps a change in learning systems could be a recommendation for students struggling with anxiety, and so studies investigating the relationship between these systems and anxiety is also recommended.

As individual teachers are unable to change the greater learning system, there should be an emphasis on research with findings that can be implemented by individual teachers to improve instruction and reduce anxiety. And with anxiety and its consequences disproportionately affecting assessments, reducing anxiety on those assessments should be of particular emphasis in future research.

Conclusion

As the primary measure of a student's knowledge and abilities, assessments are of primary importance in education. Their importance is matched by their complexity, including their format and the numerous factors that can affect their validity. Despite being widely recognized, anxiety is one such factor that has not been widely addressed. Individual teachers and some districts have demonstrated success, but wider efforts are mostly absent.

The spiral assessment strategy presented in this thesis allows individual teachers to address many of the identified causes and effects of testing anxiety independently. While no single method can comprehensively address anxiety, the spiral-testing model does address many factors implicitly, meaning these efforts will not diminish when they are not an explicit goal of the class. In this way, the assessment strategy helps combat one of the greatest impediments to student success on assessments while minimizing the time needed for everything else that requires a class's attention.

By using these assessment strategies, teachers will be incorporating numerous strategies that help reduce anxiety and its adverse effects, such explicitness of content, familiarity with format, multiple opportunities for success, diminished consequences, and regular study habits. Teachers may also implement other strategies to aid in this effort, including teaching students how to identify stress and methods to address it. Teachers can also change their own beliefs about learning and the structure of activities within their class. Regardless of their exact approach, anxiety is a very real problem that affects the performance of many students, and with many students and districts taking no action, it falls to individual

teachers to do so. This assessment strategy, along with other strategies identified from academic sources, offers teachers a variety of means to reduce the adverse effects of anxiety.

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Appendix A

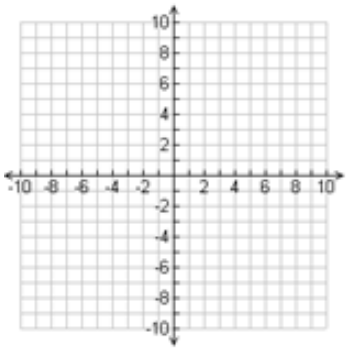
Geometry Test 7

Must show work to receive credit

1-6: Midpoint/Distance& 1-7: Transformations in the Coordinate Plane Score: _____/20

1. The coordinates of ΔABC are A(-5, 3), B(-5, -1), and C(4, -1).
   a. Find the length of $\overline{AC}$ b. Find the midpoint of $\overline{AB}$

2. The coordinates of the vertices of triangle ΔABC are A(1, 1), B(3, 1), and C(1, 8). Find the coordinates for the image of ΔABC after the transformation $(x, y) \rightarrow (x, -y)$. Draw the preimage and the image:



2-1: Inductive Reasoning & 2-2: Conditional Statements Score: _____/20

1. Determine if each conjecture is true. If not, write or draw a counterexample:
   a. If a student is in Secondary 2, then the student is in the tenth grade.

   b. The number is *2n* is even if *n* is an integer.

2. Write the converse, inverse and contrapositive of each conditional statement, then find the truth value

	Statement	Truth Value
Conditional $p \rightarrow q$	If 2 segments have the same length, then they are congruent.	
Converse $q \rightarrow p$		
Inverse $\sim p \rightarrow \sim q$		
Contrapositive $\sim q \rightarrow \sim p$		

2-3: Deductive Reasoning & 2-4: Biconditional Statements Score: _____/20

1. Determine if each conjecture is valid by the Law of Syllogism

   $If\ p \to q\ and\ q \to r\ are\ true\ statements, then\ p \to r\ is\ a\ true\ statement$

   a. Given: If it is a Friday, you take a math test. If you take a math test, it is a good day.
   Conjecture: If it is Friday, it is a good day.

   b. Given: If you take a math test, it is Friday. If you take a math test, it is a good day.
   Conjecture: If it is Friday, it is a good day.

2. Determine if a true biconditional can be written from each conditional statement. If not, give a counterexample:
   a. If a student is a sophomore, then the student is in the tenth grade.

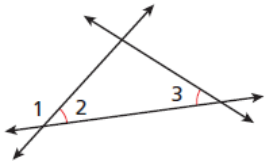
   b. The number is $2n$ is even if n is an integer.

2-5: Algebraic Proofs & 2-6: Geometric Proofs Score: _____/20

1. Fill in the blanks to complete the two-column proof:

Statements	Reasons
1. $\angle 2 \cong \angle 3$	1. Given
2. $m\angle 2 = m\angle 3$	2. a. _____
3. b. _____	3. Lin. Pair Thm.
4. $m\angle 1 + m\angle 2 = 180°$	4. Def. of supp. $\measuredangle$s
5. $m\angle 1 + m\angle 3 = 180°$	5. c. _____
6. d. _____	6. Def. of supp. $\measuredangle$s

Given: $\angle 2 \cong \angle 3$
Prove: $\angle 1$ and $\angle 3$ are supplementary.
Proof:

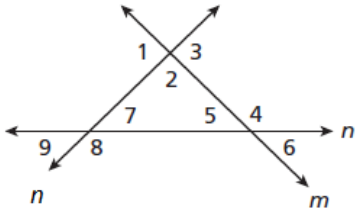


2. Complete the proof by giving the justification for each step
   Given: $\angle 3$ and $\angle 2$ are complimentary and $m\angle 1 + m\angle 2 = 90°$prove: $\angle 1 \cong \angle 3$

Statements	Reasons
_____	Given
_____	Given
_____	Definition of Complimentary Angles
_____	Transitive Property of Equality/Substitution
_____	Subtraction Property of Equality
_____	Definition of Congruent Angles

3-1: Lines/Angles & 3-2: Angles Formed by Parallel Lines and Transversal Score: _____/20

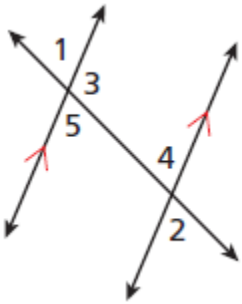
1. Use the diagram to identify the following:
   a. A pair of same-side interior angles with transversal *n*



   b. A pair of corresponding angles with transversal *m*

   c. Identify the transversal and classify ∠5 and ∠8

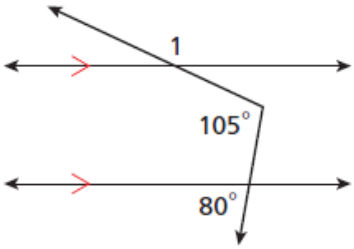
2. State the theorem or postulate that is related to the measures of the angles in each pair. Then find the angle measures.
   a. $m\angle 4 = (37x - 15)°, m\angle 5 = (44x - 29)°$



   b. $m\angle 1 = (6x + 24)°, m\angle 4 = (17x - 9)°$

Extra Credit Score: _____/10

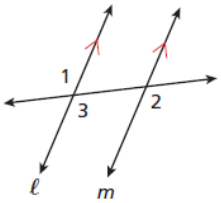
1. Find $m\angle 1$



2. Complete the two-column proof of the Alternate Exterior Angles Theorem:

Given: $\ell \parallel m$ **Prove:** $\angle 1 \cong \angle 2$

Statements	Reasons
1. $\ell \parallel m$	1. Given
2. a. _____	2. Vert. ∡ Thm.
3. $\angle 3 \cong \angle 2$	3. b. _____
4. c. _____	4. d. _____



Score _____ + Extra Credit _____ + Other _____ = Total _____

Appendix B

Geometry Test 8

Must show work to receive credit

2-1: Inductive Reasoning & 2-2: Conditional Statements Score: _____/20

3. Determine if each conjecture is true. If not, write or draw a counterexample:
   a. If an animal is moose, then it is a mammal.

   b. If an animal is a mammal, then it is a goose.

4. Write the converse, inverse and contrapositive of each conditional statement, then find the truth value

	Statement	Truth Value
Conditional $p \rightarrow q$	If two angles form a linear pair, then they are supplementary	
Converse $q \rightarrow p$		
Inverse $\sim p \rightarrow \sim q$		
Contrapositive $\sim q \rightarrow \sim p$		

2-3: Deductive Reasoning & 2-4: Biconditional Statements Score: _____/20

1. Determine if each conjecture is valid by the Law of Detachment

   $If\ p \rightarrow q\ is\ true\ and\ p\ is\ true, then\ q\ is\ true$

   a. Given: If you are taking a test, then you are happy.
      You are taking a test
      Conjecture: You are happy.

   b. Given: If the side lengths of a rectangle are 3 ft and 4 ft, then its area is 12 ft^2.
      A rectangle has side lengths of 3 ft and 4 ft.
      Conjecture: The area of the rectangle is 12 ft^2.

2. Determine if a true biconditional can be written from each conditional statement. If not, give a counterexample:
   a. If a square has side lengths of 5 m, then its area is 25 m^2.

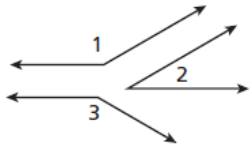
   b. If a rectangle has equal side lengths of 5 m, then the rectangle is a square.

2-5: Algebraic Proofs & 2-6: Geometric Proofs Score: _____/20

1. Fill in the blanks to complete the two-column proof:

Statements	Reasons
1. _____	1. Given
2. m∠1 + m∠2 = 180° m∠2 + m∠3 = 180°	2. Def. of supp. ≰
3. _____	3. Subst.
4. m∠2 = m∠2	4. Reflex. Prop. of =
5. m∠1 = m∠3	5. _____
6. _____	6. Def. of ≅ ≰

Given: ∠1 and ∠2 are supplementary,
∠2 and ∠3 are supplementary.
Prove: ∠1 ≅ ∠3



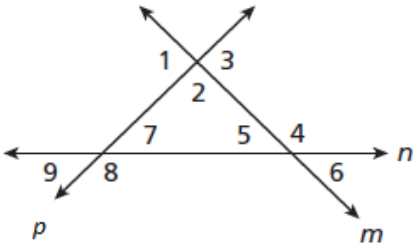
2. Complete the proof by giving the justification for each step
Given: $\overline{RT} \cong \overline{WY}$ and $ST = WX$, Prove:: $\overline{RS} \cong \overline{XY}$

Statements	**Reasons**
$\overline{RT} \cong \overline{WY}$	_____
$RT = WY$	_____
$RT = RS + ST$ and $WY = WX + XY$	_____
$RS + ST = WX + XY$	Substitution
_____	Given
$RS = XY$	_____
_____	Definition of Congruent Segments

3-1: Lines/Angles& 3-2: Angles Formed by Parallel Lines and Transversals Score: _____/20

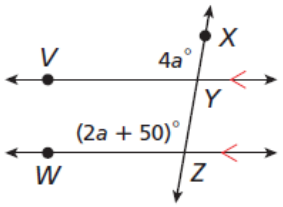
1. Use the diagram to identify the following:
   a. Identify the transversal and classify ∠3 and ∠9

   b. Identify the transversal and classify ∠1 and ∠6



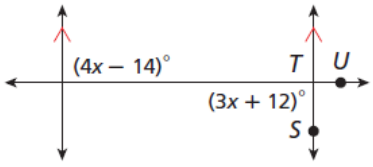
2. Find each angle measure
   a.

m∠*VYX*



   b.

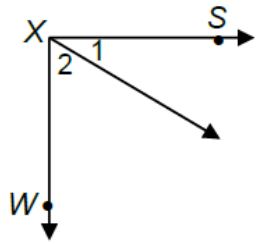
m∠*STU*



3-3: Proving Lines Parallel & 3-4: Perpendicular Lines Score: _____/20

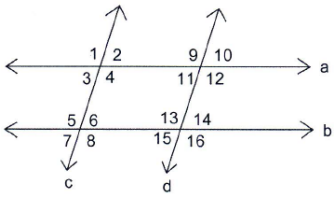
1. Given: $\angle 1$ and $\angle 2$ are complimentary, Prove: $\overline{SX} \perp \overline{WX}$

Statements	**Reasons**
$\angle 1$ and $\angle 2$ are complimentary	_____
$m\angle 1 + m\angle 2 = 90°$	_____
$m\angle WXS = m\angle 1 + m\angle 2$	_____
$m\angle WXS = 90°$	_____
$\angle WXS$ is a right angle	_____
$\overline{SX} \perp \overline{WX}$	_____



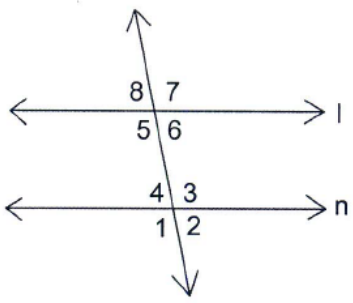
2. Given $a \parallel b$, Prove $m\angle 9 + m\angle 14 = 180°$

Statements	**Reasons**
_____	Given
$m\angle 9 + m\angle 11 = 180°$	_____
$m\angle 11 = m\angle 14$	_____
$m\angle 9 + m\angle 14 = 180°$	_____



Extra Credit Score: _____/10

3. Given $l \parallel n$, Prove: $m\angle 2 + m\angle 7 = 180°$



Score _____ + Extra Credit _____ + Other _____ = Total _____

Appendix C

Geometry Test 9

Must show work to receive credit

2-3: Deductive Reasoning & 2-4: Biconditional Statements Score: _____/20

3. Determine if each conjecture is valid by the Law of Detachment

$$If\ p \rightarrow q\ is\ true\ and\ p\ is\ true, then\ q\ is\ true$$

   a. Given: If you want to go on a field trip, you must have a signed permission slip.
   Zola has a signed permission slip.
   Conjecture: Zola wants to go on a field trip.

   b. Given: If the side lengths of a rectangle are 3 ft and 4 ft, then its area is 12 ft^2.
   A rectangle has side lengths of 3 ft and 4 ft.
   Conjecture: The area of the rectangle is 12 ft^2.

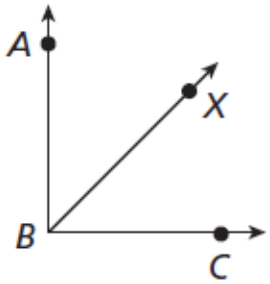
4. Determine if a true biconditional can be written from each conditional statement. If not, give a counterexample:
   a. If n is an integer, then $2n$ is even.

   b. If $a = b$, then $|a| = |b|$.

2-5: Algebraic Proofs & 2-6: Geometric Proofs Score: _____/20

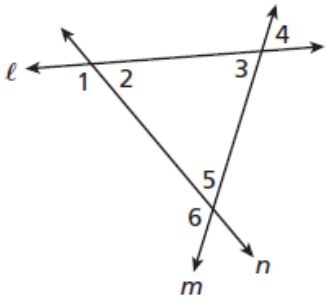
3. Complete the proof by giving the justification for each step given $\overrightarrow{BX}$ bisects $\angle ABC$ and $m\angle XBC = 45°$

1. _____	_____
2. $\angle ABX \cong \angle XBC$	_____
3. $m\angle ABX = m\angle XBC$	_____
4. $m\angle XBC = 45°$	_____
5. $m\angle ABX = 45°$	_____
6. $m\angle ABX + m\angle XBC = m\angle ABC$	_____
7. $45° + 45° = m\angle ABC$	_____
8. $90° = m\angle ABC$	_____
9. $\angle ABC$ is a right angle.	_____



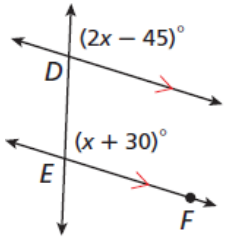
3-1: Lines/Angles & 3-2: Angles Formed by Parallel Lines and Transversals Score: _____/20

3. Use the diagram to identify the following:
   a. Identify the transversal and classify ∠2 and ∠6

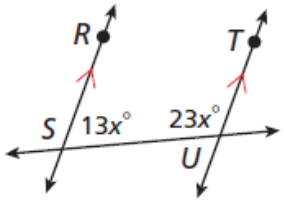


   b. Identify the transversal and classify ∠4 and ∠6

4. Find each angle measure.
   a. $m\angle DEF$



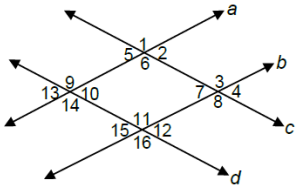
   b. $m\angle TUS$



3-3: Proving Lines Parallel & 3-4: Perpendicular Lines Score: _____/20

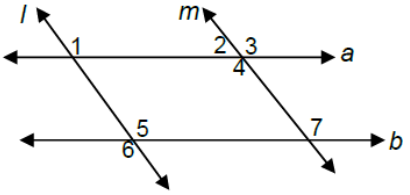
3. Given: $a||b$ and $c||d$, Prove: ∠1 ≅ ∠16

Statements	**Reasons**
_____	Given
∠1 ≅ ∠8	_____
_____	Given
∠8 ≅ ∠16	_____
_____	Transitive Property



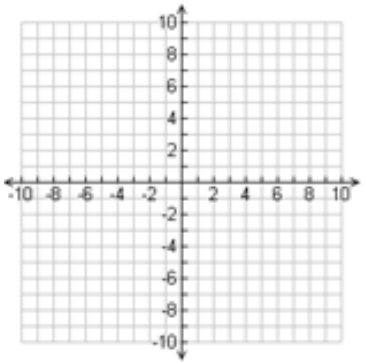
4. Given $l||m$ and ∠1 ≅ ∠7, Prove $a||b$

Statements	**Reasons**

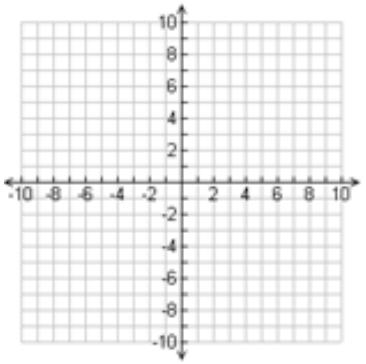


3-5: Slopes of Lines & 3-6: Lines in the Coordinate Plane Score: _____/20

1. Graph $\overleftrightarrow{XY}$ and $\overleftrightarrow{ZW}$ for $X(-2,5), Y(6,-2), Z(-3,6)$ and $W(4,0)$ and identify the slopes to determine whether the lines are parallel, perpendicular, or neither.



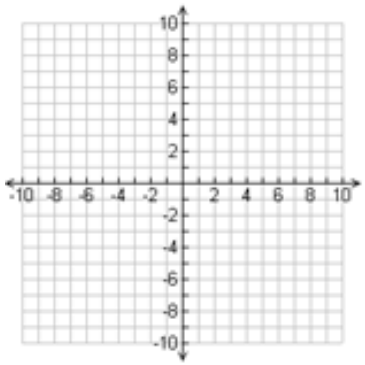
2. Line m has equation $y = -\frac{1}{2}x + 4$, and point P has coordinates (3, 5). Find the equation of line n that passes through P and is perpendicular to m. Write the equation in both slope-intercept and point-slope forms, then graph the lines m and n.



Extra Credit Score: _____/10

4. The slope of $\overleftrightarrow{AB}$ is greater than 1 and less than infinity. Write an inequality for the slope of a line perpendicular to $\overleftrightarrow{AB}$.

5. If the length of the hypotenuse of a right triangle is 17 units and the legs lie along the x-axis and y-axis, find a possible equation that describes the line that contains the hypotenuse.



Score _____ + Extra Credit _____ + Other _____ = Total _____