

# A Review of Mindfulness Research Related to Alleviating Math and Science Anxiety

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## Abstract

Defined as nonjudgmentally paying attention to the present moment (Kabat-Zinn, 1994), modern-day mindfulness has gained considerable attention in various science fields. However, despite this growth, many uses of mindfulness remain unexplored. In this paper, we focus on the application of mindfulness programs in educational settings, specifically to target math and science anxiety. Since education-related anxiety can have negative consequences on students and interfere with academic performance, researchers have begun exploring the plausibility and efficacy of implementing mindfulness programs into school curriculums to alleviate these anxious feelings. This may be particularly beneficial to math and science, as those are two fields infamously associated with anxiety yet ones that desperately need occupational growth. This paper explores the limited research connecting mindfulness to reduced test anxiety and emphasizes the need for more research directly assessing the effects of mindfulness on math and science in particular.

Although its origin stems from ancient meditation practices, mindfulness has gained considerable attention in today's society. Its applications are vast, showing beneficial outcomes in many different environments and fields of practice. John Kabat-Zinn, founder of the modern day practice, defines mindfulness as "paying attention in a particular way on purpose, in the present moment, and nonjudgmentally, to the unfolding of experience moment to moment" (1994). The practice combines three key features to promote moments of clarity: paying attention to the present moment, recognizing and classifying emotions, and experiencing more refined self-awareness in the present. Often associated with meditation and controlled breathing, mindfulness techniques can be performed formally in a structured environment or informally in everyday life. It has been used to reduce anxiety (Barbosa, Raymond, Zlotnick, Wilk, Toomey & Mitchell, 2013), lower psychological distress (Rosenzweig, Reibel, Greeson, Brainard, & Hojat, 2003), and foster a better quality of life (De Frias & Whyne, 2014). A number of mindfulness-based therapies have emerged out of the larger field, with Mindfulness-based Stress Reduction (MBSR) and Mindfulness-based Cognitive Therapy (MBCT)

being the two most notable types. This paper, however, will focus on mindfulness and its application to education and subject-specific anxiety in math and science. The need for students to be interested in science, technology, engineering, and math (STEM) is apparent, as these subjects are critical to the growth and advancement of society (Business-Higher Education Forum, 2011). Yet, schools are producing few young people interested in or qualified for a career in STEM-related fields (Business-Higher Education Forum, 2011). Based on our review of pre-existing literature, we believe that mindfulness would be an effective technique to alleviate math and science anxiety in educational settings and, as a result, draw more interested and qualified students into the STEM fields.

## Applications of Mindfulness

### Education

School remains a major source of stress among school-aged children and young adults. In a survey conducted by Harvard's School of Public Health, about 40 percent of parents indicated that school caused a great amount of stress for their high school student, and 45 percent of teens agreed by listing school as a main source of stress and suffering (NPR, 2013). Since stress can have negative effects on physical and mental health, researchers have assessed the plausibility of practicing mindfulness in educational settings in hopes of reducing stress, anxiety, and depression. Researchers at Brown University explored the idea by randomly sorting sixth-grade students into an Asian history class with daily mindfulness meditation sessions or an African history course paired with a different experiential activity (Britton, Lepp, Niles, Rocha, Fisher, & Gold, 2014). Before and after comparison of the Youth Self Report and the revised Cognitive Affective Mindfulness Measure 82% of students felt more focused after practicing meditation at least once and 88% noted a decrease in stress, anxiety, and worry (Britton et al., 2014). Similar findings were reported in another study, which assessed the effects of a nine-week long mindfulness program on a large sample of 12 to 16 year old students.

The non-randomized study assessed well-being and mental health outcomes at three different time periods: pre-intervention, post-intervention, and follow up. At the three-month follow up, the students reported fewer depressive symptoms, lower levels of stress, and greater overall well-being (Kuyken et al, 2013).

As educational stress is not exclusive to high school students, studies assessing mindfulness interventions on college populations have also shown promising outcomes. One study reviewed the effects of movement-based mindfulness courses on self-regulation, self-efficacy, mood, perceived stress, and sleep quality in 166 college students, as they too get affected by stress. It was determined that participation in a 15-week Pilates, Gyro kinesis or Taiji quan class increases mindfulness, and, in turn, improves sleep quality (Caldwell, Harrison, Adams, Quin & Greeson, 2010). Another study assessed the effectiveness of a 10-week MBSR seminar in reducing the emotional distress experienced by second-year medical students. Although the baseline total mood disturbance (TMD) was initially greater in the MBSR experimental group than the controls, the MBSR group still scored significantly lower in TMD at the completion of the study (Rosenzweig et al., 2003). These findings suggest that MBSR is an effective technique in helping medical students cope with academic stressors. The study also determined significant effects on many additional subscales including: Tension-Anxiety, Fatigue-Inertia, and Vigor-Activity (Rosenzweig et al., 2003). Likewise, Shapiro, Schwartz and Bonner (1998) examined the effects of a shorter MBSR intervention on a similar population. They found that even an 8-week program could effectively reduce self-reported anxiety and depression in pre-medical and medical students (Shapiro et al, 1998).

To assess the effectiveness of mindfulness in every niche of the academic world, researchers have conducted studies on populations of educators as well. Teachers work closely with students and play an integral role in their classroom success. This close relationship allows teachers to have a great impact on students and implies the importance of an educator's wellbeing on the classroom atmosphere. To evaluate the effectiveness of mindfulness on stress, burnout, and teaching efficacy, elementary school teachers participated in a modified Mindfulness-Based Stress Reduction (MBSR) course specifically geared towards educators and were encouraged to practice the skills obtained for 15-45 minutes each day (Flook, Goldberg, Pinger, Bonus & Davidson, 2013). Participants completed the Symptom Checklist 90-R to measure psychological distress, the Five-Facet Mindfulness Scale to assess mindfulness and self-compassion, the Maslach Burnout Inventory to evaluate burnout, and gave daily saliva samples to assess cortisol levels (Flook et al., 2013). Although this was only a pilot study with a small sample size, the final results of the study indicate that mindfulness is a promising intervention for teachers, which further supports the idea of using mindfulness in an educational setting. More specifically, the MBSR intervention improved teacher mindfulness and self-compassion, in-

creased teaching efficacy, lowered psychological burnout, and reduced attention biases (Flook et al., 2013). Focusing on a slightly different population, a second study reviewed the effects of relational mindfulness in a group of 8 teachers, counselors, and educational leaders in the 10-week program. Nonetheless, it was determined that relational mindfulness allowed the educators to better cope with the emotional challenges present in a typical school environment, thus improving their overall effectiveness as educators and leaders (Burrows, 2011). The participants were better able to engage in effective conversation with colleagues and solve problems; thus improving their overall effectiveness as educators and leaders.

### Test Anxiety

According to the American Test Anxieties Association (an organization of educators and psychologists dedicated to lessening student test anxiety), 20% of students are plagued with "severe" test anxiety, including close to 10 million children in North America alone (Driscoll, 2004). While low levels of anxiety can act as a motivator for some students, higher levels of anxiety have detrimental effects (Dobson, 2012). Test anxiety can affect a student's self-confidence, memory, and attention, which can ultimately lead to a decreased academic performance. Studies in this area of research have reported an overall negative effect of excessive anxiety on performance situations, especially at the academic level, which often goes undetected (Cunha & Paiva, 2012). Often times, these sufferers adequately prepare for their exams but fail to perform well. However, despite the prevalence of exam anxiety, it often goes undetected in many students.

Studies concentrated on mindfulness and test anxiety focus on targeting the negative consequences that result from the anxious feelings, such as increased stress levels, reduced concentration and low levels of achievement. One way to decrease the stress levels in students suffering from test anxiety is Mindfulness Based Stress Reduction (MBSR). Founded by Jon Kabat-Zinn, MBSR is a type of therapy used in clinical settings to reduce stress from pain and other related disorders. Since MBSR seems to lower levels of stress in clinical settings, practicing mindfulness in educational environments may show the same positive outcomes. If mindfulness can lower the levels of stress associated with test anxiety, then improved concentration and higher test scores should be likely to follow. One study that aimed to explore this relationship and evaluate the efficacy of mindfulness in this context found an inverse relationship between mindfulness and test anxiety (Cunha & Paiva, 2012). In this exploratory report, participants reported their personal levels of exam anxiety, self-criticism, acceptance, and mindfulness (Cunha & Paiva, 2012). Based on their initial scores, students were separated into two groups: low anxiety and high anxiety. The individuals in the high anxiety group displayed higher levels of negative self-criticism and low acceptance/mindfulness skills (Cunha & Paiva, 2012). This suggests that those with high mindfulness and acceptance

would experience less exam anxiety. Another study that further assessed this relationship determined that students with high mindfulness scores report low scores of perceived stress and maladaptive coping styles (Palmer & Rodger, 2009). These results demonstrate a positive relationship between mindfulness, rational coping and perceived stress (Palmer & Rodger, 2009).

The two main components of mindfulness are present-moment awareness and acceptance, with the latter being especially useful for students suffering from test anxiety. The acceptance approach teaches individuals to be aware of both positive and negative feelings but to react nonjudgmentally. Instead of fixating on the thoughts, they are encouraged to let them pass without interference. A study by Turkish scholars assessed the effectiveness of using this nonjudgmental awareness to fight test anxiety (Senay, Cetinkaya & Usak, 2012). 87 college freshmen were separated into either a control or experimental group and told to use either the avoidance or acceptance strategy. The results determined that both strategies were independently effective (Senay et al., 2012). Another study that aimed to assess the efficacy and role of mindfulness in an academic setting implemented a group mindfulness meditation session in a population of high school females. Despite the small sample, pre and post-test scores on the Spielberg Anxiety Test suggest that mindfulness sessions do decrease exam anxiety (Sohrabi, Mohammadi, & Delavar, 2013). Individuals also reported lower levels of emotional anxiety and worry (Sohrabi et al., 2013). In regards to the effects of mindfulness on test anxiety, one study reported no change in its participants. Paterniti (2007) randomly sorted students into a mindfulness group or a study skills group, which met for an hour a week for three weeks. During this meeting, the study skills group learned proper note taking and time management techniques, while the mindfulness group learned sitting meditation, yoga, mindful eating and body scan skills (Paterniti, 2007). It was determined that neither of the groups showed significant reductions in test anxiety, worry, or emotionality (Paterniti, 2007). However, these findings may indicate that a longer period of time is needed for the mindfulness program to yield better results.

While there is limited research assessing the effects of mindfulness on test anxiety, there are even fewer studies that specifically focus on the math and science fields. One study assessed the effects of mindfulness training on test anxiety in high school math students (Niss, 2012). Before beginning mindfulness training, students completed the Subjective Units of Distress Scale to gauge their baseline score. Then for the spring semester prior to each exam, they underwent mindfulness training where students would focus on breathing and body awareness for nine minutes (Niss, 2012). The exam scores from spring semester were compared to the fall semester, where no mindfulness exercises were completed. Results indicated some improvement in test scores between semesters and suggested that mindfulness was most helpful to students with very high levels of anxiety (Niss, 2012).

## Academic Performance and Achievement

Test anxiety, specifically the cognitive component, is detrimental to a student's academic achievement (Cassady & Johnson, 2001). Due to this relationship, mindfulness may not only reduce test anxiety but, as a result, indirectly boost academic performance as well. To further explore the link between test anxiety and performance, researchers compared anxiety scores to exam scores in a population of undergraduate students. Cassady and Johnson (2001) determined that high levels of cognitive test anxiety are correlated with lower test scores on both in-class exams and the Scholastic Aptitude Test (SAT). A similar study conducted at Hampton University explored the relationships between meditation and grade point averages (GPAs). In this educational study, participants were randomly sorted into a control group that participated in a one-hour study session or an experimental group that meditated for ten minutes prior to the study session (Hall, 1999). It was discovered that students who meditated had higher semester and cumulative GPA's (Hall, 1999). From this, we learn that meditation can have both short term and long-term effects on academic performance. Additionally, meditation seems to aid in the retrieval of information before an exam (Hall 1999) and benefit working memory capacity (Niss, 2012).

As previously mentioned the acceptance component of mindfulness seems to be particularly valuable in the realm of academics as it can reduce anxiety and improve performance. In one study, researchers created a unique mindfulness program based on acceptance and commitment therapies, and implemented it in a group of secondary students (Franco, Manas, Cangas, & Gallego 2010). The experimental group participated in one, 1.5-hour meditation session per week for ten weeks in which students were encouraged to let thoughts pass while repeating a word or mantra (Franco et al., 2010). Students in the program showed significant improvement in academic performance in addition to an increase in self-concept and decrease in anxiety (Franco et al., 2010).

## Discussion

Although limited, the results from these studies suggest that mindfulness is an effective measure to combat many issues found within the field of education. Students and educators alike are victims of stress. For students, stress can manifest itself as test anxiety, and for educators it can affect job performance and promote teacher burnout. However, these problems seem to be corrected through the practice of mindfulness. From the literature, we learn that mindfulness is helpful across a wide range of ages varying from middle school to college. Students practicing mindfulness have lower levels of stress, negative thinking, worry, and other feelings associated with anxiety (Sohrabi et al., 2013; Senay et al. 2012). They also have better grades and score higher on tests than their non-meditating peers (Hall, 1999). Similarly, teachers who practice mindfulness report lower levels of stress, display more

compassion toward their students, and are less likely to experience burnout (Flook et al., 2013). These qualities produce teachers who perform better on the job and, in turn, more positively impact their students.

The positive effects of mindfulness are apparent, but the method on how to implement a mindfulness program in a classroom remains in question. In a study comparing the efficacy of informal versus formal mindfulness programs, it was concluded that the latter seems to have a more significant effect on the student. Hindman's study (2013) assessed the effectiveness of two Mindful Stress Management programs, one that focused formal mindfulness meditation with informal practice (MSM) and one that utilized brief mindfulness exercises with informal practice (MSM-I). While both six-week programs showed positive outcomes when compared to the wait-list control group, MSM participants showed more improvement in psychological inflexibility and stress than those who partook in the MSM-I program (Hindman, 2013). These findings suggest that a formal 6-week program with informal practice would be the promising intervention for undergraduate and graduate student stress (Hindman, 2013). Incorporating a long-term, formal mindfulness program into a school curriculum would allow both students and educators to function optimally.

Although most studies concluded that mindfulness is effective in combating test anxiety, they were limited in both size and scope. Each investigation assessed mindfulness programs that varied in duration, with times ranging from a couple of weeks to several months. The studies examined also focused primarily on high school and university aged young adults, and as a result, featured small, less varied sample sizes with most participants being disproportionately Caucasian females. Furthermore, a large portion of the studies failed to include a measurement for academic performance, and only hypothesized that by lowering stress, academic performance would improve. Future studies assessing the efficacy of mindfulness programs on test anxiety should target larger and more demographically varied samples as well as statistically show the causal relationship between stress levels and academic performance.

All in all, mindfulness research has a number of positive implications for future students, educators and society as a whole. With negative feelings emerging as early as age nine, math and science are two subjects notoriously associated with feelings of anxiety and poor self-efficacy (Griggs, Rimm-Kaufman, Merritt & Patton, 2013). Since self-efficacy promotes achievement (Griggs et al, 2013), these negative feelings associated with the subjects can have a profound effect on the individual's academic career and make it difficult for the student to succeed in educational settings. Ultimately, this could steer students away from pursuing a degree in science, technology, engineering, and math - fields that desperately need growth.

Incorporating mindfulness into education may reduce test anxiety associated with science and math. The research into this topic is quite incomplete though, and hopefully these findings will prompt others to expand investigation into the subject.

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