5-2022

Effects of Environmental Variables and Student Preference On Student Achievement

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Undergraduate Honors Literature Review

High School STEM Education

June 1, 2022

Abstract

Data show Arkansas's high school graduates underperform in several national standardized tests. Research shows that positive moods warrant better academic performances. A review of the literature proves that environmental stimuli such as lights, colors, music, etc. can significantly affect a person's mental state. Research suggests that further research needs to be done. Suggestions for implementing mood-improving stimuli are provided for educators.

Keywords: Arkansas, classroom, student, mental state, stimuli

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The concept that high school students cast negative judgments upon math and science classes is not unknown to educators. In Arkansas, low standardized test results accommodate those judgements. Research suggests that better moods and attitudes result in better classroom performances (Lewine, Sommers, Waford, & Robertson, 2015). Other research suggests that the stealthy incorporation of things that students like could improve their moods (Ahmad & Rana, 2015; Kurt & Osueke, 2014).

Mood and mental states, as a generalization of the spectrum of emotions that bombard students, can be negative, neutral, or positive (Pekrun, The Control-Value Theory of Achievement Emotions: Assumptions, Corollaries, and Implications for Educational Research and Practice, 2006). A negative mood may be associated with anxiety, depression, stress, sadness, anger, discomfort, dislike, etc. In the same way, a positive mood may be associated with calmness, alertness, happiness, comfort, enjoyment, etc.

High School Students' Opinions

In the survey "What Teens Want From Their Schools" students expressed their favorite and least favorite subjects in school. Out of over 2000 students 17% reported their favorite subject being art, another 17% reported sciences, and another 15% reported math as their favorite subject. However, when asked their least favorite subject in school, 34% of the group responded math and another 9% responded with sciences (Geraci, Palmerini, Cirillo, & McDougald, 2017). Even though 32% of these high school students liked math and science, 43% disliked it and the other 25% were relatively indifferent to it. This implies that 68% of these students are in a neutral or negative mood when in these classes.

Arkansas's Underperformance

Arkansas might as well be the laughingstock of the nation in terms of academic performance. Not only is Arkansas below average in terms of ACT scores, but we also had the second lowest average AP score across the nation in 2018 at 2.211 points: the biggest loser was Mississippi with an average AP score of 2.171 (2018 AP Scores by State and Ethnicity, 2018). Additionally, in the past few years the PSAT National Merit Semifinalist Cutoff in Arkansas compared to the rest of the nation was significantly below average (See Table 1) (Sawyer, 2022). This indicates that for the amount from each state in the national competition to be fair, Arkansas has to have relatively low standards of who "the best of Arkansas" is.

Arkansas ACT Compared to National. Data show that Arkansas has been performing below the national average on the ACT test since 2003. Figures 1, 2, and 3 show that the 2013, 2014, and 2015 Arkansas graduating classes had average Composite, Math, and Science scores that were within one point of the national average scores. However, Arkansas's scores have been dropping since 2016.

Arkansas HS Unprepared for college. Data for national averages of ACT College Readiness Benchmarks from 2009 to 2019 reveal that only about a quarter of Arkansas students were graduating with the skills required to succeed in entry-level college courses (See Figure 4). The percentage of students in Arkansas that reached the ACT's College Readiness Benchmarks peaked in math in 2012 with 36% of graduates receiving scores that indicated that they would have a 75% chance of passing a College Algebra class with a C (ACT, Inc., 2009).

How Mental States Affect Cognitive Performance

Mental states and moods have proven to directly affect cognitive performance. On one end of the spectrum are negative headspaces and poorer performances compared to neutral

headspaces and performances. On the other end of the mental state spectrum, studies have found correlations between positive emotions and higher performance. These studies suggest that classroom teachers should be trying to sustain neutral emotions in the classroom or induce positive emotions in order to maximize a student's potential for performance.

Positive emotions have been proven to increase both engagement levels and learning (Pekrun, Goetz, Frenzel, Barchfeld, & Perry, 2011). One 2015 study tested the effects of an induced positive mood on critical thinking. The study proved its ability to induce a positive mood in both male and female university students, however only the female students reported experiencing higher energy after the positive mood induction and increased performance (Lewine, Sommers, Waford, & Robertson, 2015).

Investigations show that negative emotions negatively affect student performance. While stress may induce higher learning for some students, stress affect memory storage and retrieval which ultimately leads to bad grades for most students. There seems to exist a stress-load sweet spot that maximizes learning without overwhelming the student (Vogel & Schwabe, 2016). Unlike stress, other negative emotions such as anger, anxiety, and shame have consistently proven to have negative effects on student learning and performance (Pekrun, Goetz, Frenzel, Barchfeld, & Perry, 2011).

Research on the effects of worry and anxiety on working memory show that while in these negative mental states, cognitive performance is directly affected. A 2016 study showed that students with higher worry levels performed worse than their equal working memory peers in algebra. This affected students with low working memory the most by drastically decreasing their performances (Trezise & Reeve, 2016). Similarly, a 2019 study proved that test anxiety caused slower responses regarding working memory. There was a direct correlation between a

student's anxiety level and their response time in higher anxiety students (Angelidis, Solis, Lautenbach, Does, & Putman, 2019). These studies' results encourage the current practices of increasing test time for individuals with test anxiety.

Although not as direct of a correlation to mental states and student performance, a 2019 study of older adults concluded that participants with mental state disorders such as bipolar disorder and depression had lower visuospatial memory performance. To note, the study mentioned that the lower performance may have been due to medication use, but it argued that not all of the differences should have been medicinally related (Cullen, et al., 2019). This study is uniquely informative if the responses of the older adults is comparable to students. If students with mood disorders perform poorly in the classroom, it follows that their performance may be hindered by their disorder or the medications they are taking. So, even if a student does not seem to have a mental state disorder because their medications are effective at keeping them "normal," then their disorder or medication might be negatively affecting their performance.

How Environmental Variables Affect Mental State

Overview

Mental states are directly linked to sensory inputs and therefore environmental variables. It follows that producing pleasant environments encourages positive mental states (Edmunds, 2020). Meaning that pleasing environmental variables need to be experienced to induce a pleasing mental state. A 2020 study determined that youths with disruptive mood dysregulation disorders and other emotional disturbances had significant sensory processing difficulties compared to typical youths (Benarous, et al., 2020). Due to the interconnected nature of senses and moods, this study begs the question "If these mentally disturbed youths were able to fully process their environment, would their mental states improve?"

Ocular Stimuli

Several studies concerning light and color correlate these ocular stimuli with both positive and negative resulting mental states. Color and color psychology have been extensively studied to provide insights on how differences in saturations can affect feelings of softness and activity. In general, warm colors like reds, oranges, and yellows are seen as higher energy colors than cool colors like greens, blues, and purples (Kurt & Osueke, 2014). The following studies agree with the 2021 literature review of sensory stimulation and mood which summarized that exposure to bright light decreased depression and therefore improved mental states (Canbeyli, 2021).

A 2015 study found that when anxiety was produced in the participants, they preferred cozy ambiences that increased their pleasure and reduced arousal instead of neutral ambiences. In the same study, it was determined that when sadness was induced, the participants preferred activating ambiences that increased their pleasure and arousal. It is important to note that this particular study's participants were elderly persons and that previous studies of this age group were used to determine that a cozy ambience was dimmer orange light compared to the normal brightness white light and that the activating ambience was a brighter blue light (Kuijsters, Redi, Ruyter, & Heynderickx, 2015).

A 2021 study on random university students in their twenties tried to find a connection between moods induced by lighting and the mood's resulting impact on creative performance. They found that brighter than average warm light decreased their mood while standard brightness of warm light and brighter light with cooler tones increased mood (Lan, Hadji, Xia, & Lian, 2021). A similar 2019 study of young adults with light-induced mood found that bright cool light and dim warm light caused positive moods (Zhu, et al., 2019).

A 2020 study of random Australian community members thirteen and above and not legally blind focused on finding a connection between colors of different rooms and mental states. Subjects were exposed to combinations of different rooms and colors using virtual reality. The most consistent results were that blue-hued colored rooms were more likely to induce positive mental states. However, blue was not the only color that made the public feel positive: it was simply the most consistent. Also important is that the study revealed that pink-toned rooms decreased any positive effects of any other rooms, including the blue hues (Lipson-Smith, et al., 2020).

A 2014 color study on college students in their public spaces revealed that over 62% of students preferred the bright yellow and green space with graffiti-like artwork and athletic posters on the wall over the red themed geometrically decorated area or the two muted brown, gray, and white rooms with classy decorations. In this study, 64% of the students reported their favorite colors to be blue, green, and yellow with 60% the of students reporting that brown, orange, and grey were their least favorite colors. (Kurt & Osueke, 2014). These percentages suggest that the students' favorite colors might have influenced their perception and moods of the different environments.

The two studies concerning light brightness and temperature agree that brighter light with bluer hues decreased sadness and increased mood. Similarly, the Australian study indicated that in the absence of pink tones, blue hues were the most effective and consistent room color that increased mental state. Based on the 2014 color study of college students, the tendency of participants to increase their mood in bright bluer stimuli might be influenced by that participants affinity toward bluer hues. Even so, due to the breadth of these studies, bluer and brighter

environments seem to be the most effective at inducing positive mental states, especially compared to redder hues or muted colors.

Aural Stimuli

There is compelling evidence that auditory stimuli can affect someone's mental state (Canbeyli, 2021). In a survey on people's emotional responses to music, it concluded that over 91% of the people in the study were affected by music in some way. Subcategories of music were examined with calming music leaving 87% of participants in a more positive state and 66% in a calmer state. Sad music reportedly made 87% of participants sadder and happy music made over 85% happier. Most participants agreed that music is positive in most scenarios; 90% of participants agreed that music sooths the soul, and 60% of participants agreed that music improves people's mood. In addition, this study found that 83.6% of the participants responded positively when they heard their favorite music (Ahmad & Rana, 2015).

Music and music therapy have been extensively studied in healthcare scenarios. In a 2015 study among adult psychiatric inpatients, they found that every group exposed to therapy, being active music therapy, receptive music therapy, and cognitive behavioral therapy experienced increased mood. However, the group that received receptive music therapy where the patients listened to music and individually reflected on its effect showed the greatest improvement (Markovich & Tatsumi, 2015). A study of cancer patients that were subjected to solitary confinement found that music therapy of live music and the option to participate decreased social confinement and significantly increased mood (Doro, Neto, Cunha, & Doro, 2017). Yet another study of music and mood over the course of two years found that patients that received music therapy twice a week experienced significant increases in mood. This 2020 study also assessed the feasibility of such intervention and determined that it was incredibly feasible and helpful for

the patients in improving mood and engagement in rehabilitation (Street, et al., 2020). Additionally, a 2021 study on the effects of music therapy and mood patients found that the group exposed to music therapy had large improvements in attention, mood, and well-being compared to the control group that received conventional occupational therapy (Chan, Ng, Leung, Chui, & So, 2021).

In summary, listening to music has proven to increase mood in a variety of situations. Other auditory stimuli such as listening to the sounds of nature has also proven to decrease stress and improve mood. A 2020 study proved that virtual nature was more useful than traditional mindfulness behavioral therapy (Reynolds, et al., 2020). This study along with the previously mentioned studies also suggest that not only is auditory stimuli and music therapy effective at improving mood, but it is also often equally as effective or more effective than traditional forms of therapy.

Tactile Stimuli

While it is difficult to assess the tactile stimulus present in every situation, there are certain aspects of physical nature that affect mood. One such example is a 2021 study where university students were assigned to sit upright or stooped postures. The students who were assigned to sit upright experienced increased mood from their posture (Awad, Debatin, & Ziegler, 2021). Another possible interpretation of tactile stimulus is the presence of animals in the classroom. A 2017 literature review concluded that in most settings animals, particularly exposure to dogs, affected students positively in mental states affecting behavior and other physiological responses (Brelsford, Meints, Gee, & Pfeffer, 2017).

Olfactory Stimuli

A literature review of the effects of inhalation of essential oils summarized (a) citrus, chamomile, rosemary, lavender, and lavender combinations decreased anxiety (b) citrus, lavender, and sage all had positive effects on mood (c) citrus, chamomile, lavender, and a lavender/rose combination all function as antidepressants and (d) lavender was proven to reduce stress (Fung, Lau, Ngai, & Tsang, 2021). In total, lavender was proven to increase mental state in several different ways suggesting that it is the perfect scent for increasing mood in a classroom setting. However, a 2021 newspaper article suggests that teachers utilize lavender to calm and relax students but to use citrus to increase energy and focus (Deal, 2021). The 2021 literature review of sensory stimulation and mood specifically mentions the known positive effects of not only citrus and lavender, but of vanilla, lemon oil, and cedar wood (Canbeyli, 2021). If the students in the classroom are not too sensitive to aerosols, then having multiple scents in the classroom for different days seems to be appropriate.

Conclusions

The data gathered for this review shows that students in Arkansas need educational intervention. However, directly improving problem solving skills, cognitive acuity, or other school-related talents across the state is an endeavor beyond the scope of a single paper. Instead, this paper illuminates the connection between emotional state and academic performance. With depressed, anxious, or stressed students in mind, possible environmental changes and improvements are explored that the common school or classroom teacher could implement to help improve student mood and therefore academic performance.

Though the studies used in this review vary in design and audience, there are patterns that emerge concerning most sensory inputs. In general, brighter cooler-toned lights improved mood.

There is also a whisper of evidence that seeing one's favorite color improves mood. Auditory inputs such as music have proven to improve moods, with nature sounds being particularly effective. Another way to improve a student's mood is to have them improve their posture. Additionally, there are several olfactory stimuli to increase mood such as chamomile, rose, citrus, and lavender.

Strengths, Weaknesses, and Research

Overall, the strengths of this review are also the weaknesses. The breath of studies used lends itself to the conclusion that these mood-improving stimuli are universal. However, the studies referenced were of a large variety from medical studies to suggestions in a newspaper to informal student surveys. There are not many studies directly relating environmental factors to student mental states. In addition, there was not enough data for certain stimuli like tactile and taste to form any reputable conclusions.

This paper undoubtedly shows the lack of research in several areas related to this paper. Deliberate study of students with different environmental inputs is highly recommended. These studies need to focus on the direct mental effects of students in classrooms as well as focusing on the cognitive benefits of these environmental interventions. Moreover, research should be conducted to determine any unintentional effects students may experience. Additionally, the ability of teachers and schools to perform any suggested interventions also requires attention. Cost-benefit analysis must be done comparing painting rooms, installing window, and replacing light bulbs for visual stimulation. Analysis of the investment of individual music devices or classroom speakers for auditory stimulation and analysis of different olfactory sensation delivery devices is also highly recommended.

Suggestions for Educators

Educators are encouraged to make sure their classrooms are bright with cool tones to decrease depression and increase arousal on a day-to-day basis. However, on test day students may benefit from a dimmer and warmer-toned environment. In the same way, educators are encouraged to have different scents available for different situations. Citrus is shown to improve mood and arousal, possibly best used on a day-to-day basis, while lavender is common for reducing stress, for example on test day.

The implementation of positive music and nature sounds can improve mood in several ways. Just the inclusion of positive audio a couple days a week can affect student mood daily basis. Educators are recommended to include music in any way into the classroom. For some classes with older students, music may only be appropriate between classes. Other classes may only be able to utilize music during review games. For others, audio can be incorporated during independent reading, study, or problem-solving.

Educators are also urged to practice and encourage an upright posture; slouching encourages sadness and sleepiness. A suggestion that requires a larger commitment is the inclusion of a classroom pet. While animals that can be placed on a desk and fit in small terrarium or cage are more popular classroom pets, exposure to larger mammals such as dogs is particularly effective in increasing mood. As mentioned previously, the reality of implementing these suggestions is unknown, but the hope of helping students with these suggestions remains.

References

2018 AP Scores by State and Ethnicity. (2018, November 1). *Higher ED Data Stories*. Retrieved from https://www.highereddatastories.com/2018/11/2018-ap-scores-by-state-and-ethnicity.html

ACT, Inc. (2009). *Measuring College and Career Readiness: The Class of 2009.* ACT, Inc. Retrieved from https://www.act.org/content/dam/act/unsecured/documents/ACT_Arkansas_Output.pdf

ACT, Inc. (2013). *Average ACT Scores by State Graduating Class 2013.* ACT, Inc. Retrieved from https://www.act.org/content/dam/act/unsecured/documents/CCCR13-StatebyStateScoreSummary.pdf

ACT, Inc. (2014). *The Condition of College & Career Readiness 2014: Arkansas.* ACT, Inc. Retrieved from https://www.act.org/content/dam/act/unsecured/documents/CCCR-2014-Arkansas.pdf

ACT, Inc. (2018). *The Condition of College & Career Readiness 2018: Arkansas Key Findings.* ACT, Inc. Retrieved from https://act.org/content/dam/act/unsecured/documents/cccr2018/Arkansas-CCCR-2018.pdf

ACT, Inc. (2019). *The Condition of College & Career Readiness 2019: Arkansas Key Findings.* ACT, Inc. Retrieved from https://act.org/content/dam/act/unsecured/documents/cccr-2019/Arkansas-CCCR-2019.pdf

Ahmad, N., & Rana, A. (2015). *Impact of Music on Mood: Empirical Investigation.* Retrieved from https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2696883

Angelidis, A., Solis, E., Lautenbach, F., Does, W. v., & Putman, P. (2019, February 7). I'm going to fail! Acute cognitive performance anxiety increases threat-interference and impairs WM performance. *PLoS ONE*.

Awad, S., Debatin, T., & Ziegler, A. (2021, June 16). Embodiment: I sat, I felt, I performed - Posture effects on mood and cognitive performance. *Acta Psychologica*.

Benarous, X., Bury, V., Lahaye, H., Desrosiers, L., Cohen, D., & Guile, J. M. (2020, March 23). Sensory Processing Difficulties in Youths with Disruptive Mood Dysregulation Disorder. *Frontiers in Psychiatry*.

Brelsford, V. L., Meints, K., Gee, N. R., & Pfeffer, K. (2017, June 22). Animal-Assisted Interventions in the Classroom-A Systematic Review. *International Journal of Environmental Research and Public Health*.

Canbeyli, R. (2021, October 20). Sensory stimulation via the visual, auditory, olfactory and gustatory systems can modulate mood and depression. *European Journal of Neuroscience*, pp. 244-263.

Chan, K. H., Ng, C. W., Leung, K. H., Chui, P. F., & So, C. T. (2021, June). Music in improving attention and mood in attention-impaired patients in a geriatric day hospital. *Asian Journal of Gerontology & Geriatrics*, pp. 59-60.

Cullen, B., Smith, D. J., Deary, I. J., Pell, J. P., Keyes, K. M., & Evans, J. J. (2019). Understanding cognitive impairment in mood disorders: mediation analyses in the UK Biobank cohort. *The British Journal of Psychiatry*, pp. 683-690.

Deal, C. (2021, August 6). How the smell of a classroom affects mood and learning. *The Times Educational Supplement*.

Doro, C. A., Neto, J. Z., Cunha, R., & Doro, M. P. (2017). Music therapy improves the mood of patients undergoing hematopoietic stem cells transplantation (controlled randomized study). *Support Care Cancer*, pp. 1013-1018.

Edmunds, D. R. (2020, February 13). Israeli researchers discover thoughts, moods and sensory inputs connected. *The Jerusalem Post (Online)*.

Fung, T. K., Lau, B. W., Ngai, S. P., & Tsang, H. W. (2021, May 3). Therapeutic Effect and Mechanisms of Essential Oils in Mood Disorders: Interaction between the Nervous and Respiratory Systems. *International Journal of Molecular Sciences*.

Geraci, J., Palmerini, M., Cirillo, P., & McDougald, V. (2017). *What Teens Want from Their Schools: A National Survey of High School Student Engagement.* Thomas B. Fordham Institute. Retrieved from https://fordhaminstitute.org/sites/default/files/%2806.27%29%20Complete%20Survey%20Results%20-%20What%20Teens%20Want%20From%20Their%20Schools.pdf

Kuijsters, A., Redi, J., Ruyter, B. d., & Heynderickx, I. (2015, July 20). Lighting to Make You Feel Better: Improving the Mood of Elderly People with Affective Ambiences. *PLoS ONE*.

Kurt, S., & Osueke, K. K. (2014). The Effects of Color on the Moods of College Students. *SAGE Open, 4*(1). doi:10.1177/2158244014525423

Lan, L., Hadji, S., Xia, L., & Lian, Z. (2021, April 15). The effects of light illuminance and correlated color temperature on mood and creativity. *Building Simulation*, pp. 463-475.

Lewine, R., Sommers, A., Waford, R., & Robertson, C. (2015). Setting the Mood for Critical Thinking in the Classroom. *International Journal for the Scholarship of Teaching and Learning, 9*(2). Retrieved from https://files.eric.ed.gov/fulltext/EJ1134530.pdf

Lipson-Smith, R., Bernhardt, J., Zamuner, E., Churilov, L., Busietta, N., & Moratti, D. (2020, October 19). Exploring colour in context using Virtual Reality: Does a room change how you feel? *Virtual Reality*, pp. 631-345.

Markovich, R., & Tatsumi, K. (2015). The Effects of Single-Session Music Therapy Interventions in Comparison with a Cognitive Behavior Intervention on Mood with Adult Psychiatric Inpatients in an Acute-Care Setting: A Quasi-Experimental Trial. *Music Therapy Perspectives*, pp. 118-127.

Pekrun, R. (2006). The Control-Value Theory of Achievement Emotions: Assumptions, Corollaries, and Implications for Educational Research and Practice. *Educational Psychology Review, 18*, 315-351. doi:10.1007/s10648-006-9029-9

Pekrun, R., Goetz, T., Frenzel, A. C., Barchfeld, P., & Perry, R. P. (2011). Measuring emotions in students' learning and performance: The Achievement Emotions Quesionnaire (AEQ). *Contemporary Educational Psychology, 36*(1), 36-38. doi:10.1016/j.cedpsych.2010.10.002

Reynolds, L., Rogers, O., Benford, A., Ingwaldson, A., Vu, B., Holstege, T., & Alvarado, K. (2020, May 20). Virtual Nature as an Intervention for Reducing Stress and Improving Mood in People with Substance Use Disorder. *Journal of Addiction*.

Sawyer, A. (2022, May 5). *National Merit Semifinalist Cutoffs Class of 2023*. Retrieved from Compass Education Group: https://www.compassprep.com/national-merit-semifinalist-cutoffs/

Street, A., Zhang, J., Pethers, S., Wiffen, L., Bond, K., & Palmer, H. (2020). Neurologic music therapy in multidisciplinary acute stroke rehailityation: Could it be feasible and helpful? *Topics in Stroke Rehabilitation*, pp. 541-552.

Trezise, K., & Reeve, R. A. (2016). Worry and working memory influence each other interatively over time. *Cognition and Emotion, 30*(2), 353-368. doi:10.1080/02699931.2014.1002755

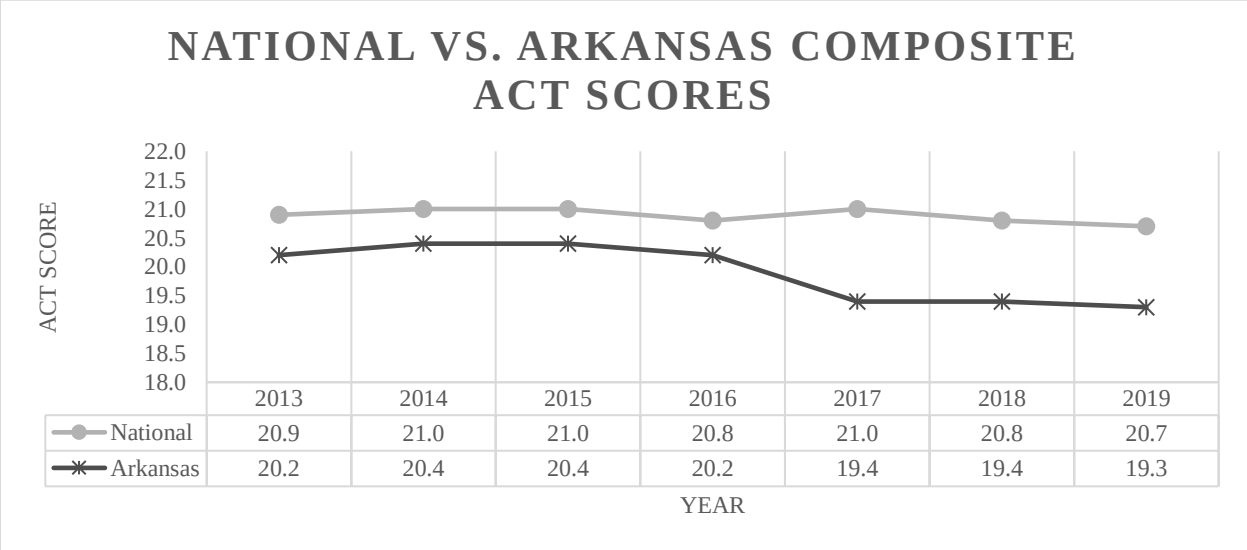
Vogel, S., & Schwabe, L. (2016). Learning and memory under stress: implications for the classroom. *Science of Learning, 1*. doi:10.1038/npjscilearn.2016.11

Zhu, Y., Yang, M., Yao, Y., Xiong, X., Li, X., Zhou, G., & Ma, N. (2019). Effects of Illuminance and Correlated Color Temperature on Daytime Cognitive Performance, Subjective Mood, and Alertness in Healthy Adults. *Environment and Behavior*, pp. 199-230.

Figures

Figure 1

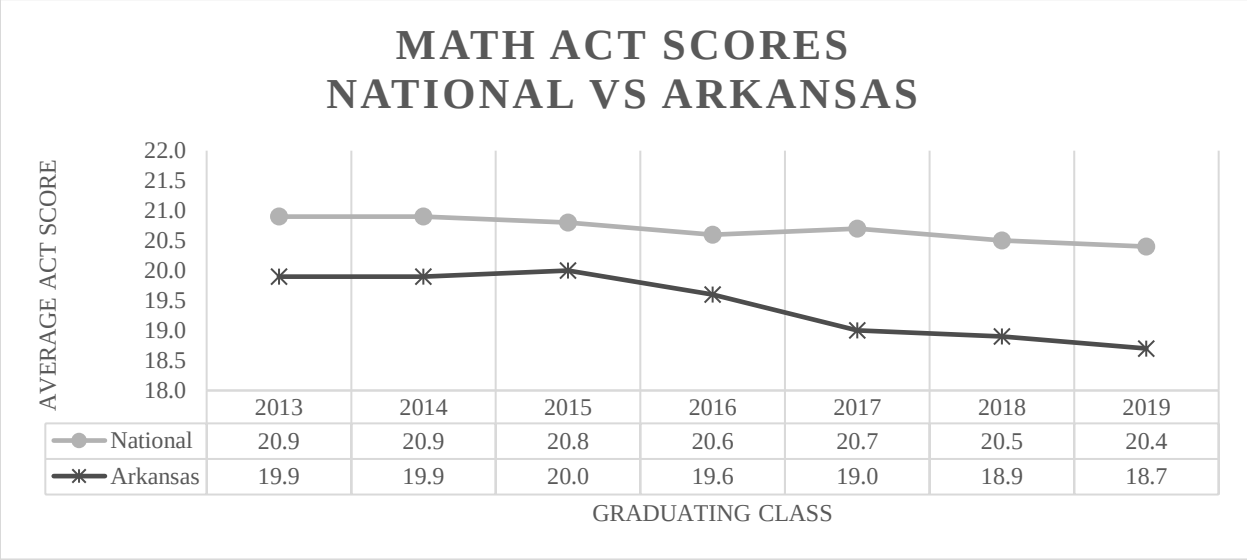
National and Arkansas Average Composite ACT Scores of Classes 2013 to 2019



Note: The data for 2013 Average Composite Scores are from *Average ACT Scores by State Graduating Class 2013*. Copyright 2013 by ACT Inc (ACT, Inc., 2013). The data for 2014-2018 Average Composite Scores are from *The Condition of College & Career Readiness 2018: Arkansas Key Findings.* Copyright 2018 by ACT Inc (ACT, Inc., 2018). The data for 2019 Average Composite Scores are from *The Condition of College & Career Readiness 2019: Arkansas Key Findings.* Copyright 2019 by ACT Inc (ACT, Inc., 2019).

Figure 2

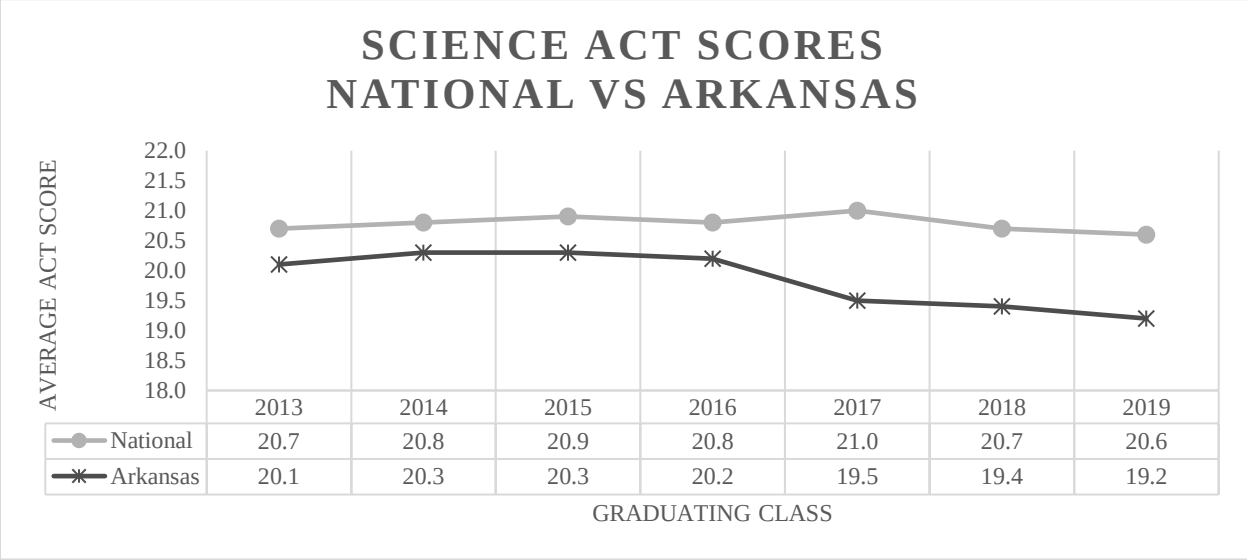
National and Arkansas Average Mathematics ACT Scores of Classes 2013 to 2019



Note: The data for 2013 Average Mathematics Scores are from *Average ACT Scores by State Graduating Class 2013*. Copyright 2013 by ACT Inc (ACT, Inc., 2013). The data for 2014-2018 Average Math Scores are from *The Condition of College & Career Readiness 2018: Arkansas Key Findings.* Copyright 2018 by ACT Inc (ACT, Inc., 2018). The data for 2019 Average Math Scores are from *The Condition of College & Career Readiness 2019: Arkansas Key Findings.* Copyright 2019 by ACT Inc (ACT, Inc., 2019).

Figure 3

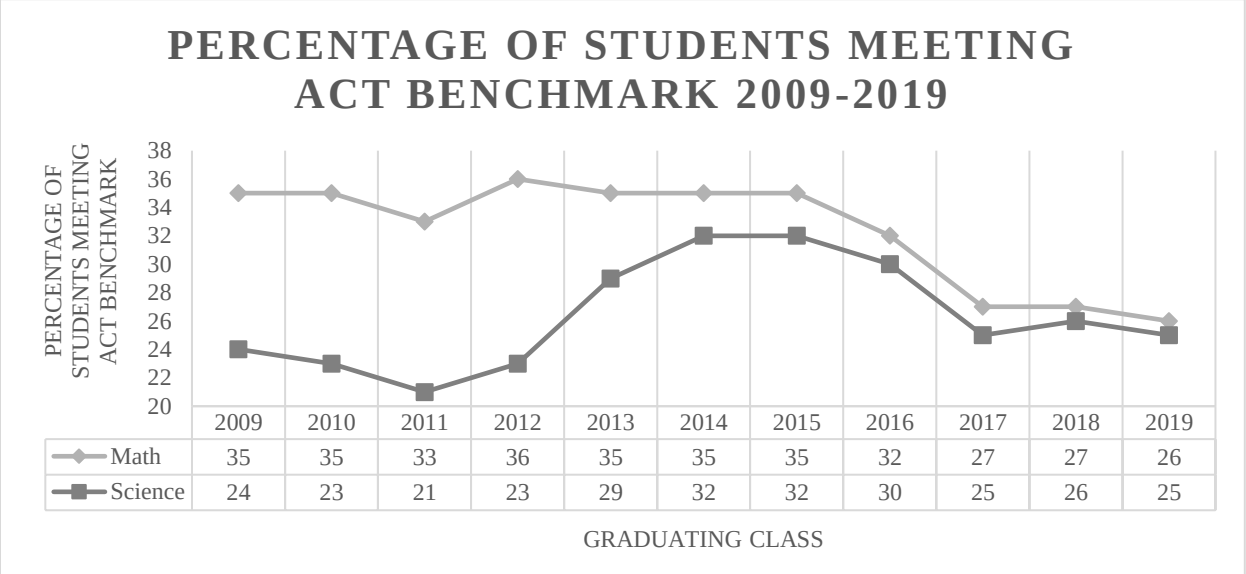
National and Arkansas Average Science ACT Scores of Classes 2013 to 2019



Note: The data for 2013 Average Science Scores are from *Average ACT Scores by State Graduating Class 2013*. Copyright 2013 by ACT Inc (ACT, Inc., 2013). The data for 2014-2018 Average Science Scores are from *The Condition of College & Career Readiness 2018: Arkansas Key Findings.* Copyright 2018 by ACT Inc (ACT, Inc., 2018). The data for 2019 Average Science Scores are from *The Condition of College & Career Readiness 2019: Arkansas Key Findings.* Copyright 2019 by ACT Inc (ACT, Inc., 2019).

Figure 4

Percentage of Students Meeting ACT Benchmarks in Math and Science Classes 2009 to 2019



Note: The required score for meeting math ACT Benchmarks is 22. The required score for meeting science ACT Benchmarks was 24 before 2013 and 23 after 2013 (ACT, Inc., 2009, 2014). The data for 2009 Benchmarks are from *Measuring College and Career Readiness: The Class of 2009.* Copyright 2009 by ACT Inc (ACT, Inc., 2009). The data for 2010-2014 Benchmarks are from *The Condition of College & Career Readiness 2014: Arkansas.* Copyright 2014 by ACT Inc (ACT, Inc., 2014). The data for 2015-2019 Benchmarks are from *The Condition of College & Career Readiness 2019: Arkansas Key Findings.* Copyright 2019 by ACT Inc (ACT, Inc., 2019).

Tables

Table 1

The PSAT National Merit Semifinalist Cutoff Comparison from 2020-2023

Year	2020	2021	2022	Predicted 2023
Lowest Cutoff Score	212	209	207	207
Arkansas' Cutoff score	214	212	211	212
Highest Cutoff Score	223	222	224	223

Note: Derived from "National Merit Semifinalist Cutoffs Class of 2023" (Sawyer, 2022).