Incubating Career Knowledge and Interest Through In-School STEM Labs

Report on MidAmerica 2023 Data

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Background

Many students from rural communities in the United States often leave school without adequate preparation for careers in science, technology, engineering, and mathematics (STEM) (Saw & Agger, 2021). When compared to students in urban communities, rural students often face disparities in access to educational and training opportunities in STEM (Harris & Hodges, 2018). These barriers include attending schools with tight budgets, having educators with limited confidence in or knowledge of STEM content, fewer opportunities for STEM programming in out-of-school time, and "brain drain" as educated adults move to urban areas after completing their STEM degrees (Carr & Kefalas, 2009; Cromartie et al., 2015; Hunter et al., 2020; Saw & Agger, 2021).

Some regions have recognized the need to invest in STEM education to retain talent and promote economic growth. For instance, Oklahoma has brought together partners from education, industry, and government to develop a strategic plan for the state to promote the idea that "a good STEM foundation in education leads to greater employment opportunities and careers, both in existing, established companies and in in young, small entrepreneurial business;" this plan even highlights that the impact of these STEM opportunities "leads directly to improvement in the wellbeing and way of life for all citizens in Oklahoma" (Oklahoma Governor's Science & Technology Council, 2016). Alignment of strategy across government, education and industry sectors is particularly important to northeast Oklahoma.

Energy, manufacturing, and technology companies have settled in northeast Oklahoma, particularly in the MidAmerica Industrial Park. MidAmerica Industrial Park is Oklahoma's largest industrial park with 80 firms including seven Fortune 500 companies. The industries present at MidAmerica "are built upon an educated and well-trained STEM workforce" (Oklahoma Governor's Science & Technology Council, 2016). As such, the community of northeast Oklahoma is motivated to prepare their students for STEM opportunities, and the MidAmerica STEM Alliance has developed a cross-sectional collaboration to ensure their local students maintain their interest in STEM while in school in order to graduate ready for STEM careers.

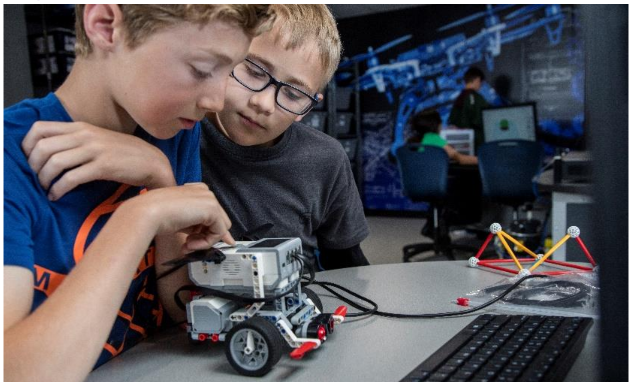
MidAmerica STEM Alliance's In-School STEM Labs

MidAmerica STEM Alliance (MidAmerica) coordinates the expertise, resources, and enthusiasm of partners within the MidAmerica Industrial Park, connecting local students with workforce development experiences. These experiences both improve STEM skills and "provide insight to real-world applications" of STEM learning (MidAmerica STEM Alliance, 2021). MidAmerica is particularly focused on providing STEM resources in school districts in northeastern Oklahoma. Before MidAmerica's involvement, these districts' robotics clubs, agriculture education, and career technology had strong presences, but theses STEM programs struggled with limited capacity, resources, and facilities to match the student demand for STEM learning experiences. To address this issue, MidAmerica established its model of in-school STEM labs.

The in-school STEM lab is a program delivery model that goes beyond providing student STEM learning opportunities. MidAmerica provides the funding and support to physically transform the schools so that the learning environments have state-of-the-art STEM labs (**Figure 1**). Through this initiative, educators in these schools are trained on student engagement and STEM learning facilitation, and each summer educators across schools are convened to share best practices. The STEM labs use cutting-edge curricula and a hands-on approach with authentic materials and technology. To inspire students' career interest in STEM, educators invites industry partners, including professionals and subject matter experts, to work with students. Finally, MidAmerica provides students with opportunites outside of the classroom to continue to engage in STEM learning as they seek further technical or career-oriented skills.

In 2016, these in-school STEM Labs were established in five Mayes County school districts. During this time, the Oklahoma School Superintendent noted that the partnership between MidAmerica Industrial Park and the county "'serves as a model to what we would like to see throughout the state'"(News on 6, 2016, p. 6). Since then, the model has grown to 18 school districts and continues to produce a measurable impact on its students. Today, MidAmerica serves nearly 1,300 students in 4th - 12th grades through its in-school STEM labs.

Figure 1. Students at In-School STEM Labs



Data Collection

In January and February 2023, MidAmerica collected data on their in-school STEM lab using PEAR's Common Instrument Suite – Student Survey (CIS-S) and Common Instrument Suite – Educator Survey (CIS-E). Data was collected in 9 schools and included 610 students in grades 4 through 12, as well as 9 educators.

The CIS-S is a 56-item youth self-report measure of six STEM attitudes (STEM activities, career interest and knowledge, engagement, enjoyment, and identity) and four social-emotional skills (critical thinking, perseverance, relationships with peers, and relationships with adults (Allen et al., 2020; Noam et al., 2020; Sneider & Noam, 2019). Reliabilities for these scales were high, ranging from 0.80 to 0.93 (Allen et al., 2019). Items are rated on a 4-point Likert scale from "Strongly Disagree" to "Strongly Agree." The CIS-S was administered at the end of spring programming in a Retrospective Pretest-Posttest (RPP) format. In this format, students rate each item two frames of reference: before starting their STEM lab (retro-pre) and the day of their survey (retro-post). Two versions of the survey were administered to students. Older students in sixth grade and above took the full CIS-S which consisted of all 10 scales. Younger students in fourth through fifth grades took a shortened version of the CIS-S which consisted of six scales: the four social-emotional skills and two STEM attitudes (STEM engagement and identity).

The CIS-E is an educator self-report survey that asks educators about several aspects of being a STEM educator. In addition to program context (e.g., where STEM activities are taking place), educators are asked to rate their perceptions of their own STEM identities on a 4-point Likert scale from "Strongly Disagree" to "Strongly Agree," the ease of implementing practices aligned with high-quality programming on a 4-point Likert scale from "Very Hard" to "Very Easy," and their perceptions of change in their students' STEM confidence, STEM skills, and social-emotional skills on a 4-point Likert scale from "Not at All Confident/Skilled" to "Very Confident/Skilled." Reliabilities for these scales are also high, ranging from 0.74 to 0.94 (Allen et al., 2019; Price, 2018).

Common Instrument Suite Survey Findings

Student Demographics

In January and February 2023, 610 students completed the CIS-S survey (**Table 1**). Slightly under half (45%) of the surveyed student were boys, over one-third (36%) were girls, and the remainder preferred to self-describe (8%) or not to answer (11%) their gender identity. Fourth through twelfth graders were represented in this sample. The majority (64%) of students were in elementary grades (4^{th} and 5^{th}), with middle school grades (6^{th} through 8^{th}) comprising 8% and high school grades (9^{th} through 12^{th}) making up 28%. In terms of the race/ethnicity distribution, the greatest proportion (26%) of students preferred not to answer. Of the students who did identify their race/ethnicity, the groups with the largest representation were White, Caucasian (non-Hispanic) ("White") (23% of the whole sample); American Indian, Native American, or Alaskan Native ("Native American") (20% of the whole sample); and multiracial/multiethnic ("multiracial") (15% of the whole sample). Lastly, nearly all (94%) students primarily spoke English at home.

Table 1. Student (n = 610) Demographics

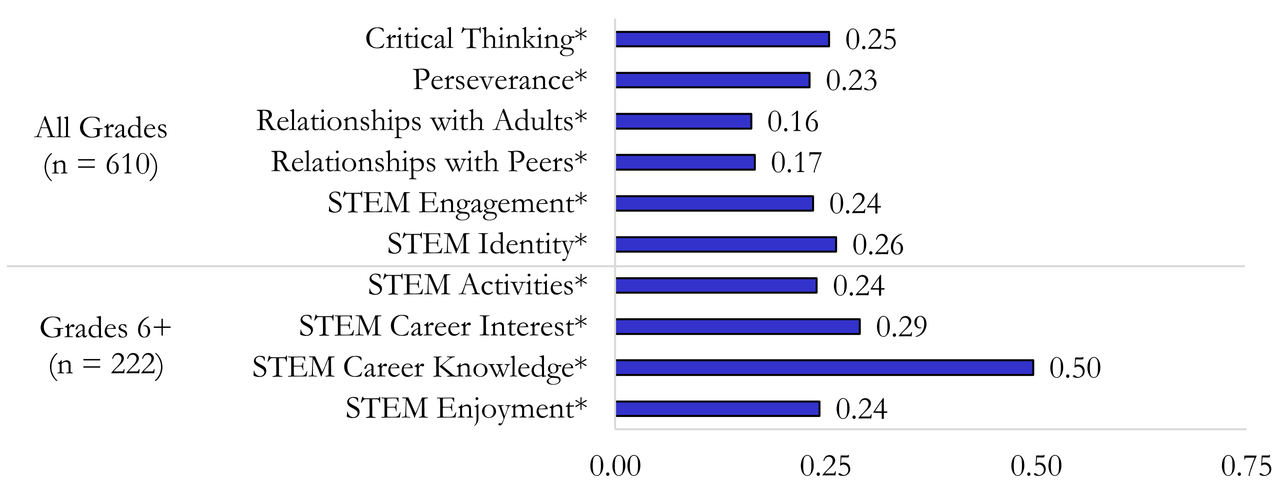
Variable	Sample Size (%)
Gender	
Boy	268 (45%)
Girl	215 (36%)
Prefer to self-describe	47 (8%)
Prefer not to answer	67 (11%)
Grade	
Elementary (4^{th}-5^{th} grades)	388 (64%)
Middle (6^{th}-8^{th} grades)	49 (8%)
High (9^{th}-12^{th} grades)	173 (28%)
Race/Ethnicity	
African-American, Black	13 (2%)
American Indian, Native-American, or Alaskan Native	122 (20%)
Asian, Asian-American	15 (3%)
White, Caucasian (non-Hispanic)	138 (23%)
Multiracial/multiethnic	90 (15%)
Prefer not to answer	156 (26%)
Prefer to self-describe	53 (9%)
Caribbean Islander, Latino or Hispanic, or Native Hawaiian, Pacific Islander	10 (2%)
Primary Language Spoken at Home	
English	554 (93%)
Non-English	23 (4%)
Prefer not to answer	20 (3%)

Student Outcomes

To examine the results from the six STEM-related attitudes and four 21^{st}-century skills, we computed difference scores for each scale. These scores were calculated by subtracting each retro-post mean from its retro-pre mean. Then, these difference scores were analyzed to see if they differed significantly from zero, which indicates no change from retro-pre to retro-post. If the *p*-value of a given scale was below 0.05, its mean difference is considered statistically significant, meaning that the change is unlikely to be a result of chance.

Across the entire sample, students reported statistically significant differences (p's < 0.001) on all 10 scales (**Figure 2**). These differences were all in the positive direction. To examine the magnitude of this change, we computed effect sizes for all scales using Cohen's *d*: critical thinking ($d = 0.44$), perseverance ($d = 0.38$), relationships with adults ($d = 0.27$), relationships with peers ($d = 0.28$), STEM engagement ($d = 0.47$), STEM activities ($d = 0.42$), STEM career interest ($d = 0.38$), STEM career knowledge ($d = 0.62$), STEM enjoyment ($d = 0.32$), and STEM

Figure 2. Student-Reported Change in CIS-S Outcomes (n = 610), MidAmerica STEM Alliance, 2023



identity (*d* = 0.41). The effect size for STEM career knowledge is considered a medium effect, whereas the effect sizes for the other nine scales are considered small effects (Cohen, 2009).

Additional analyses were completed to investigate potential demographic differences in CIS-S outcomes. Across male and female students, there were no statistically significant differences on any of the CIS-S scales. Of the students who identified their race/ethnicity, we looked at the top three represented race categories to see if there were outcome differences across White, Native American, and multiracial students. Across these race categories, there were statistically significant differences on only 2 of the 10 scales (p's < 0.05): STEM engagement and STEM identity. For STEM engagement, White students reported significantly greater change than Native American. For STEM identity, White and multiracial students reported significantly greater change than Native American students. However, it is important to note that Native American students reported significantly greater baseline scores (i.e., retro-pre means) than White students for these two scales (p's < 0.05).

Educator Perceptions

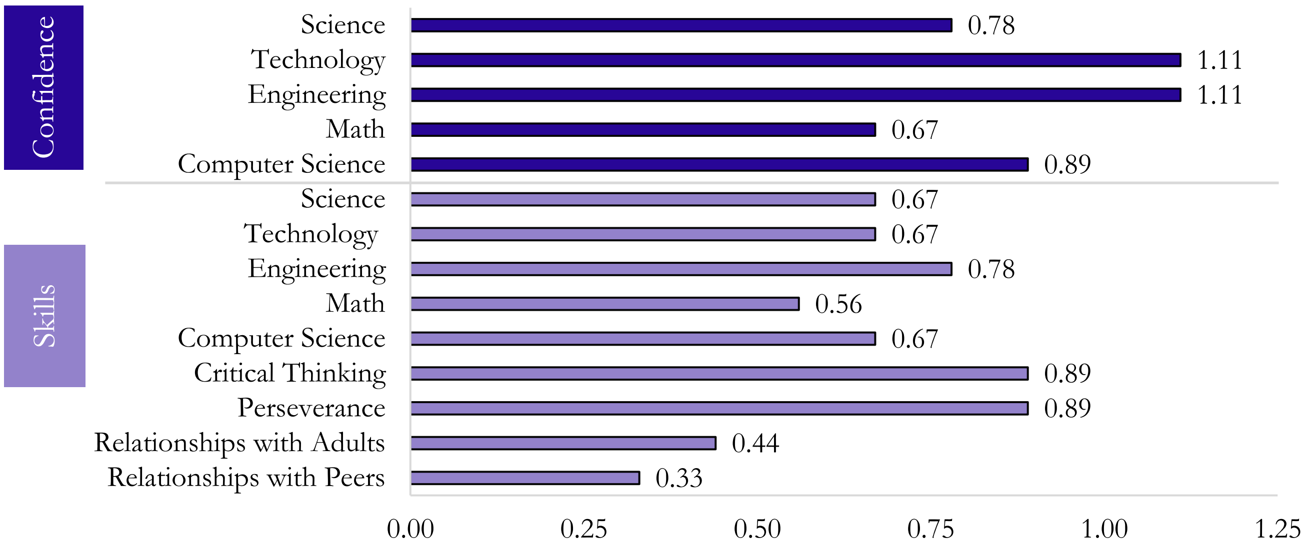
In January and February 2023, 9 educators, representing 9 different schools facilitating MidAmerica's in-school STEM labs completed the CIS-E survey. The gender distribution of these educators skewed slightly towards women (78%), with men comprising the remaining 22%. The largest race/ethnicity groups represented among these educators were White, Caucasian (62%) and American Indian, Native American, or Alaskan Native (15%). Their highest levels of education were split between those who had attained a bachelor's degree (56%) and those with a master's degree (44%). These educators had between two and eight years of experience leading in-school STEM activities. Notably, one-third (33%) of educators had 7 years of in-school STEM experience.

When asked about their training and professional development, the vast majority (78%) felt that they had enough training and support to lead STEM activities. Within the last year, 44% of educators had between 10-15 hours of STEM-related professional development. This professional development likely includes the annual summer conference for MidAmerica STEM labs' educators. When asked "What kind of STEM training/support would you like to receive?" on the survey, educators suggested "material management/curriculum mapping," "observ[ing] others who have been facilitators longer than I have," "First Lego League," and the "summer institute."

In addition to collecting data about educator characteristics, the CIS-E asks educators about their own STEM identities, attitudes towards teaching STEM over time, and ability to use practices that are associated with high-quality STEM learning. On a scale from 1 to 4, educators' average STEM identity was 3.44. All educators reported positive changes in their attitudes towards leading STEM; they all reported feeling more comfortable, confident, interested in, and capable teaching STEM on their survey date compared to a year prior. Educators also self-assessed their ability to use teaching practices aligned with PEAR's Dimensions of Success, a framework for assessing high-quality STEM learning experiences (Shah et al., 2018). On average, educators reported that all 15 practices were "somewhat easy." The two DoS-aligned practices with the highest ratings included "supporting students to share their ideas and opinions," and "choosing activities that allow for the hands-on exploration of STEM content."

Educators were also asked to rate their perceptions of students' confidence and skills at two time points: before their participation in the STEM lab and at the time of their survey date. On average, educators reported growth in students' confidence across all STEM domains, as well growth in students' skills related to STEM, computer science, and 21st-century learning (**Figure 3**).

Figure 3. Averages Difference Scores in Educators' Perceptions of Students' Confidence Levels and Skills (n = 9), MidAmerica STEM Alliance, 2023



Summary

MidAmerica's student and educator data demonstrate how participation in their in-school STEM labs increase students' STEM-related attitudes and 21st-century skills. Students in these labs reported significant positive changes in all ten 21st-century and STEM outcomes, with the greatest positive changes in STEM career interest and STEM career knowledge. Based on common effect size benchmarks, MidAmerica's STEM labs had a medium effect on career knowledge (Cohen, 2009). To contextualize this finding, the effect sizes of STEM career interest and career knowledge for MidAmerica STEM labs' students exceed those found in a meta-analysis of 74 studies on the mathematics achievement in K-12 classrooms with access to cutting-edge curricular technology and materials (Cheung & Slavin, 2013). Although MidAmerica's in-school STEM labs encompass all aspects of STEM – not just mathematics – this comparison is still of note. As for MidAmerica's goal of preparing students for Oklahoma's workforce, previous research suggests that students with greater STEM career knowledge are more likely to choose STEM careers (Blotnicky et al., 2018).

In addition to STEM-related attitudes, MidAmerica's STEM labs also enabled growth in critical 21st-century skills, such as critical thinking, perseverance, and relationships with adults and peers. This growth may be because MidAmerica is able to leverage the benefits of rural communities. These communities' smaller populations have been shown to allow closer relationships to form across contexts (e.g., family, school community) than those found in urban and suburban areas Previous research has shown that the time and space needed to develop the social-emotional skills – including strong relationships with adults – that can enhance academic achievement happen in out-of-school programs (Noam & Shah, 2014; Yohalem & Wilson-Ahlstrom, 2010). However, MidAmerica's STEM in-school labs illustrate that the development of these skills can be successfully embedded in the school building and into the school day.

Further, MidAmerica students' positive results did not differ much by student demographics. The few differences observed by race/ethnicity may be due to the higher baseline STEM-attitudes of Native American students. The largest minority group represented in the districts with MidAmerica's in-school STEM labs entered the academic year with an enthusiasm for STEM that was maintained throughout the program. MidAmerica leaders have heard from educators that the STEM learning opportunities are a huge motivator for their students and may be a huge factor in their choice to return to school each day.

Educators reported high levels of comfort, interest, confidence, and capability leading STEM at the beginning of the year that either was maintained or increased. As a number of these teachers cited the MidAmerica-supported summer convening as the training they would like to receive, this finding suggests that this convening is valuable. This small sample of evidence is consistent with previous research that shows that "providing teachers with opportunities to learn about the materials they will use with students…is associated with improved student outcomes"(Lynch et al., 2019). This group of educators has experience in teaching in-school STEM, but the fact they are continuing to build confidence may illustrate their willingness to embrace MidAmerica's new approach to in-school STEM learning. However, additional data would be necessary to relate the STEM Alliance's professional support directly to the teachers' comfort, interest, confidence, and capability increases. Nonetheless, the student-reported baseline and change data and teacher buy-in indicate that northeast Oklahoma is ready and willing to prepare its students to enter the STEM workforce.

MidAmerica STEM Alliance provides the facilities and supports to deepen and extend students' commitment to STEM learning during the school day within a high-quality STEM environment. These STEM labs allow student to envision how STEM connects to their future career goals from day one. Therefore, the partnerships between industry and education that make MidAmerica STEM Alliance's in-school STEM labs possible may be moving the needle on preparing a strong future STEM workforce for Oklahoma.

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Learn More

- Visit MidAmerica Industrial Park's website.
- PEAR's website to learn more about our STEM tools and services.

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