Challenging the Status Quo Through In-School STEM Learning in Putnam County, FL

Report on 2022-2023 Data Collection

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Background

Employment opportunities in science, technology, engineering, and math (STEM) in the United States are expected to rise between 2021 and 2031 (U.S. Bureau of Labor Statistics, 2022). However, there is a shortage of STEM-ready professionals across America and companies are finding it difficult to meet STEM workforce needs (Florida Regional STEM2 Hub, 2020). To prepare students to successfully move from the classroom into STEM careers, two key factors are proficiency and interest in STEM (Beier & Rittmayer, 2009; Business-Higher Education Forum, 2011). Yet, interest in STEM tends to decrease across students as they get older and many students struggle to reach proficiency, with 60% of students failing to meet mathematical proficiency in fourth grade and 64% of students failing to meet science proficiency (NAEP, 2019a, 2019b; Wieselmann et al., 2020).

Students from socioeconomically disadvantaged communities are particularly susceptible to these issues and overwhelmingly attend under-resourced schools with less experienced teachers and fewer STEM coursework opportunities (Lynch et al., 2019; Tyson et al., 2007). Early exposure to STEM and access to STEM courses, particularly those that emphasize hands-on learning, are important for increasing STEM interest and proficiency (littleBits & YouGov, 2018; NAEP, 2019b). However, only 18% of fourth graders report engaging in scientific inquiry-related classroom activities on a weekly basis (NAEP, 2019b). By coupling increased frequency of authentic STEM learning opportunities with teacher professional development, schools may be able to disrupt these trends and bolster student STEM outcomes (Lynch et al., 2019).

Northeast Florida Regional STEM2 Hub

STEM2 Hub

Science | Technology | Engineering | Mathematics | Medicine

STEM2 Hub is a nonprofit organization that builds cross-community systems to ensure all students have access to high-quality STEM learning experiences to "accelerate the growth of STEM2 Hub education and careers." Through engaging the local community and cultivating high-impact cross-sector relationships with schools, education-focused organizations (e.g., LEGO Education, Woz Education, Code.org), industry partners (e.g., Microsoft), out-of-school time providers and government, STEM2 Hub empowers educators and students to explore STEM career pathways, pursue critical 21st-century workforce skills, and cultivate a sense of belonging in STEM.

Figure 1. Students participating in a coding challenge.

STEM2 Hub regularly reaches over 100,000 students through supporting in-school and out-of-school programming in coding, robotics, computer science, mathematics, real-world STEM problem-solving and more. With an integrated approach that focuses on educator professional development along with scaffolded and progressively-aligned student learning, STEM2 Hub works with school district leaders to systematically align curriculum across all schools.

With a particular focus on computational thinking and the intersection between coding and math, STEM2 Hub collaborates to build strong teachers, engaging programs, and interested students. STEM2 Hub develops resources that weave together in-school and after-school learning through competitions, camps, and afterschool programs with a goal of nurturing a deeper understanding of in-school STEM learning and promoting STEM career exploration. Through collaborating to offer STEM learning opportunities in a variety of contexts, STEM2 Hub strives to equip students from all backgrounds with experiences to build resiliency and workforce readiness so that all students have access to the skills and knowledge needed to building tomorrow's workforce and strong and thriving communities.

Putnam County School District

Putnam County School District serves a high proportion of students from economically disadvantaged backgrounds (94.7%) and students attending these schools tend to report lower Math and Science proficiency rates compared to statewide Florida rates (Florida Department of Education, 2022). Previously, more than half of Putnam County Schools ranked in the bottom 3% of schools in Florida (Richardson, 2023). However, the current Superintendent of Putnam County Schools, Dr. Richard Surrency, has worked diligently to improve students' academic success and in consequence, Putnam's high school graduation rates have increased from 55% in 2015 to 93% in 2021 (Richardson, 2023). This dramatic improvement can be largely attributed to the implementation of STEM education (Richardson, 2023). In 2017, STEM2 Hub partnered with Putnam County School District to help them gain a better understanding of the STEM learning landscape among students. Based on findings from a student STEM outcomes assessment among 6th graders, Putnam County redesigned their STEM curriculum, increased exposure to STEM for all students, and strengthened the "culture of collaboration" among educators (Richardson, 2023). Now, Pre-K students are regularly exposed to STEM learning activities like building with Legos, K-5th grade students engage in one STEM class per week focused on STEM topics like coding, 6th grade students participate in a daily STEM course and have STEM integrated into their other classes, and 7th-12th students choose STEM elective courses to participate in such as Aerospace and Drone Technologies, Robotics, Cybersecurity, Computer Science, and Artificial Intelligence/Machine Learning many of which lead to industry certifications (Richardson, 2023).

Data Collection

The current data collection efforts were used to monitor outcomes from the Putnam County STEM initiative and provide insight into effective strategies that schools and districts can use to systematically increase equitable access to STEM.

In December 2022 through February 2023, Northeast Florida Regional STEM2 Hub collected data from Putnam County School students and educators using PEAR's Common Instrument Suite – Student Survey (CIS-S) and Common Instrument Suite – Educator Survey (CIS-E). Data was collected from 1,317 students in fourth through twelfth grades across 11 Putnam County Schools, as well as 44 educators across 8 Putnam County Schools.

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 mid-school year in a Retrospective Pretest-Posttest (RPP) format. In this format, students rate each item from two frames of reference: before starting their STEM course (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).

Table 1. Student Demographics (n = 1,317)

Variable	Sample size (%)
School	
Browning Pearce Elem.	182 (14%)
James A. Long Elem.	117 (9%)
Kelley Smith Elem.	225 (17%)
Melrose Elem.	91 (7%)
Ochwilla Elem.	104 (8%)
Robert H. Jenkins Elem.	240 (18%)
William D. Moseley Elem.	107 (8%)
Crescent City Jr.-Sr. High	73 (6%)
Interlachen Jr.-Sr. High	66 (5%)
Palatka Jr.-Sr. High	26 (2%)
QI Roberts Jr.-Sr. High	86 (7%)
Gender	
Female	577 (44%)
Male	618 (47%)
Prefer not to answer	122 (9%)
Grade	
Fourth	282 (21%)
Fifth	345 (26%)
Sixth	437 (33%)
Seventh – Twelfth	251 (20%)
Race/Ethnicity	
African-American, Black	198 (15%)
American Indian, Native-American	53 (4%)
Asian, Asian-American	20 (2%)
Latino or Hispanic	88 (7%)
White, Caucasian (non-Hispanic)	335 (25%)
Multi-Race	179 (14%)
Not listed	155 (12%)
Prefer not to answer	282 (21%)
Primary Language	
English	1,146 (87%)
Non-English	90 (7%)
Prefer not to answer	81 (6%)

Common Instrument Suite Survey Findings

Student Demographics

Between December 2022 and February 2023, 1,317 Putnam County students in grades 4-12 completed the CIS-S RPP. **Table 1** reports the demographics of these students. The vast majority of student data (81%) was collected from seven Putnam County Elementary Schools (grades K-6). The remaining data (20%) was collected from four Putnam County Junior-Senior High Schools (grades 7-12). Nearly half of the students in the sample were boys (47%), over two-fifths were girls (44%), and the remainder preferred not to answer (9%). Two-fifths of students were in fourth grade (21%), a little over a quarter were in fifth grade (26%), a third were in sixth grade (33%), and the remaining two-fifths were in seventh through twelfth grade (20%). The distribution of students' racial and ethnic identities revealed that about a quarter of students identified as White, Caucasian (non-Hispanic) (25%) and approximately two-fifths preferred not to answer (21%). The other major racial identities represented were African-American, Black (15%), Multi-Race (14%), unlisted (14%), and Latino or Hispanic (7%). The remaining students (6%) identified as American Indian, Native-American (4%), Asian, Asian-American (2%), Caribbean Islander (<1%), Native Hawaiian or Other Pacific Islander (<1%), and Middle Eastern or Arab (<1%). The majority of students (87%) spoke English as their primary language at home.

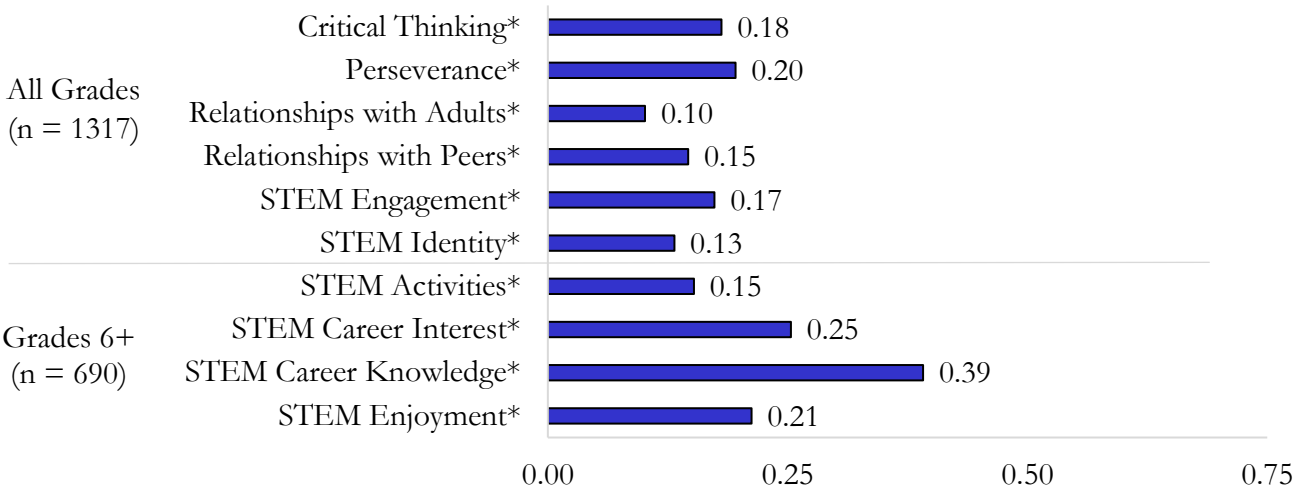
Student Overall Outcomes

To examine the results from the six STEM-related attitudes and four 21st-century skills, we computed difference scores for each scale. These scores were calculated by subtracting each retro-pre mean from its retro-post 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 student sample, analysis revealed statistically significant positive change (p's < 0.001) on all 10 scales (**Figure 2**). To examine the magnitude of this change, we computed effect sizes for all scales using Cohen's *d*: critical thinking ($d = 0.34$), perseverance ($d = 0.34$), relationships with adults ($d = 0.19$), relationships with peers ($d = 0.24$), STEM engagement ($d = 0.37$), STEM identity ($d = 0.23$), STEM activities ($d = 0.26$), STEM career interest ($d = 0.40$), STEM career knowledge ($d = 0.58$), STEM enjoyment ($d = 0.34$). The effect size for STEM career

knowledge is considered medium, whereas the effect sizes for the other nine scales are considered small effects (Cohen, 2009). Similarly, when we examined overall outcomes for only students in 4th-6th grade (i.e., elementary school students), analysis revealed statistically significant positive change (*p*'s < 0.001) on all 10 scales with medium effects on STEM career knowledge and small effects on the other nine scales.

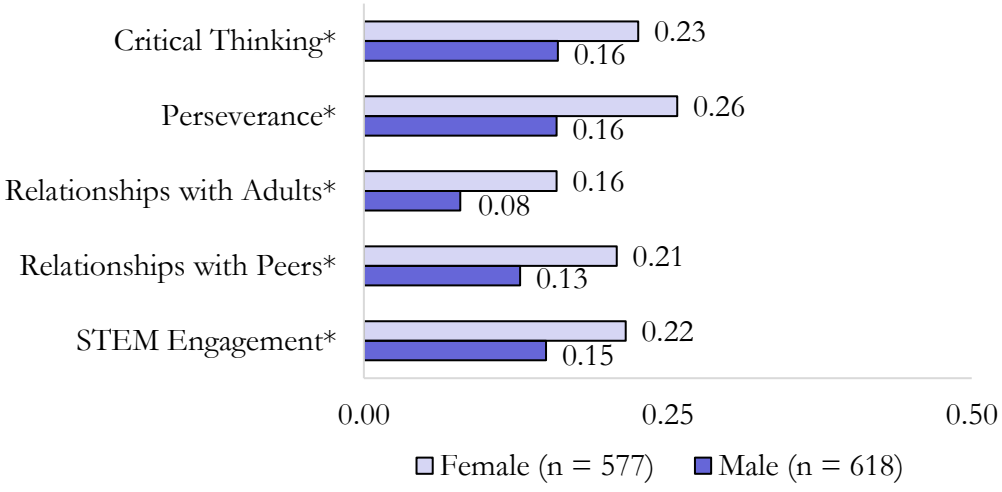
Figure 2. Student-Reported Change in CIS-S Outcomes (n = 1,317), Northeast Florida Regional STEM2 Hub, 2022-2023



Student Outcomes by Gender and Race/Ethnicity

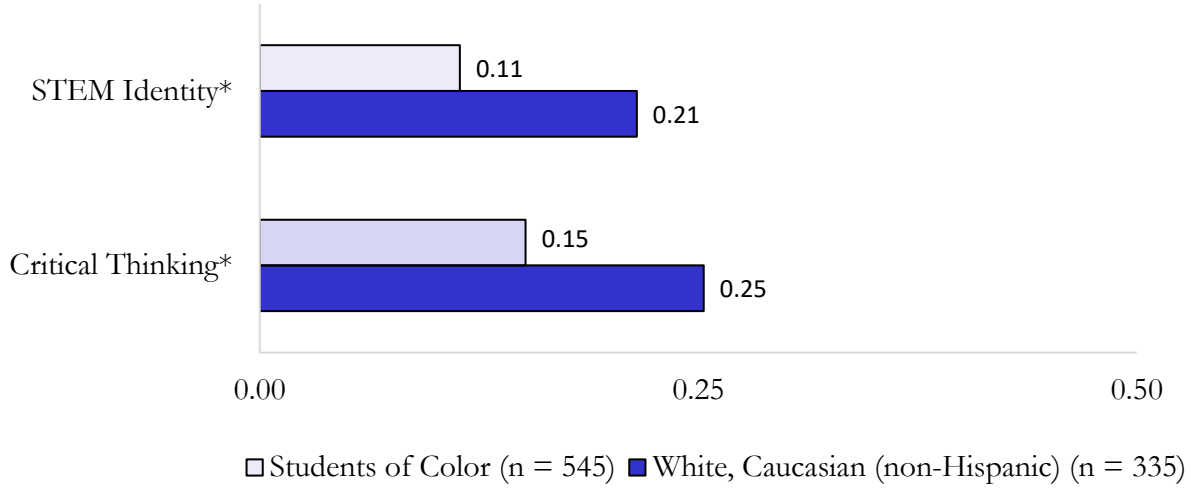
Additional analyses were computed to investigate potential gender and race/ethnicity differences in CIS-S outcomes. Across female and male students, there were significant differences on 5 of the 10 scales (*p*'s < 0.05) (**Figure 3**). These scales were STEM engagement, critical thinking, perseverance, relationships with adults, and relationships with peers. On all scales with significant differences, females reported more positive change than males. To further explore the relationship between gender and outcomes, we conducted a moderation analysis to examine how gender impacts the strength of the relationship between retro-pre and retro-post scores for each scale. Findings revealed that among female and male students, gender had a significant effect on the relationship between retro-pre and retro-post scores on 4 of the 10 scales (*p*'s < 0.05). These scales were STEM career knowledge, STEM career interest, relationships with adults, and relationships with peers.

Figure 3. Significant Differences in CIS-S Outcomes by Gender (n = 1,195), Northeast Florida Regional STEM2 Hub, 2022-2023



In addition to outcome differences across gender, we analyzed outcome differences by race/ethnicity, specifically between students of color and White, Caucasian students. Across these two race/ethnicity categories, there were significant differences on 2 of the 10 scales (*p*'s< 0.05): STEM identity and critical thinking (**Figure 4**). On both STEM identity and critical thinking scales, White, Caucasian (non-Hispanic) students reported greater increases than students of color.

Figure 4. Significant Differences in CIS-S Outcomes by Race/Ethnicity (n = 880), Northeast Florida Regional STEM2 Hub, 2022-2023



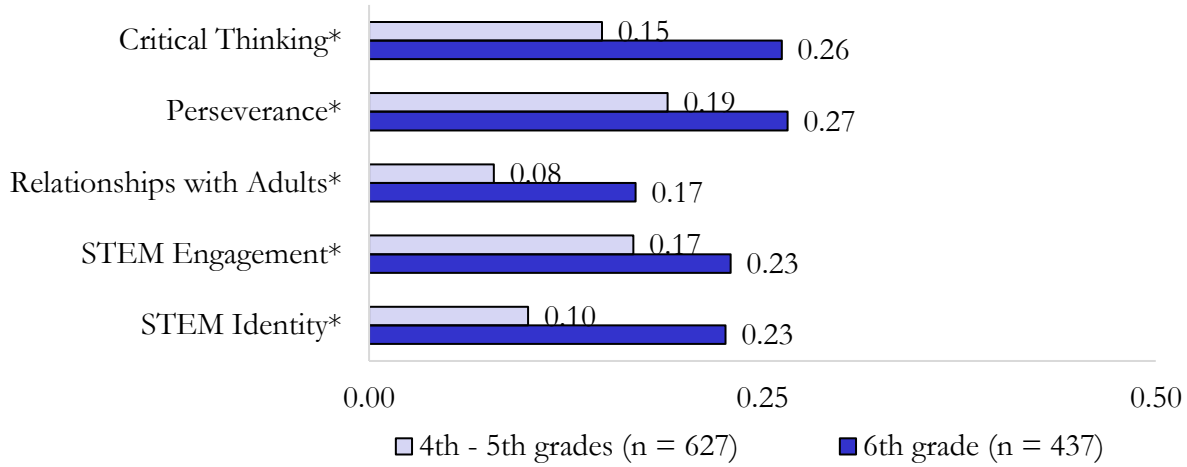
Student Outcomes by Grade

Across grade groups (4th-6th, 7th-8th, 9th-12th), there were significant differences on 7 of the 10 scales (*p*'s < 0.05). There scales were STEM activities, STEM career interest, STEM career knowledge, STEM engagement, STEM enjoyment, STEM identity, and perseverance.

Analyses were also conducted to examine differences between 6th grade students and students in other grades to better understand the impact of STEM dosage on CIS-S outcomes. Between 6th grade students and students in all other grades, there were significant differences on all 10 scales (*p*'s < 0.05) such that 6th grade students reported greater increases from retro-pre to retro-post on all scales compared to students in other grades. Between 6th grade students and 4th-5th grade students, there were significant differences on 5 of the 6 CIS-S scales (*p*'s < 0.05) (**Figure 5**). These scales were STEM engagement, STEM identity, critical thinking, perseverance, and relationships with adults. Across all scales with significant differences, 6th grade students reported greater increases than 4th-5th grade students.

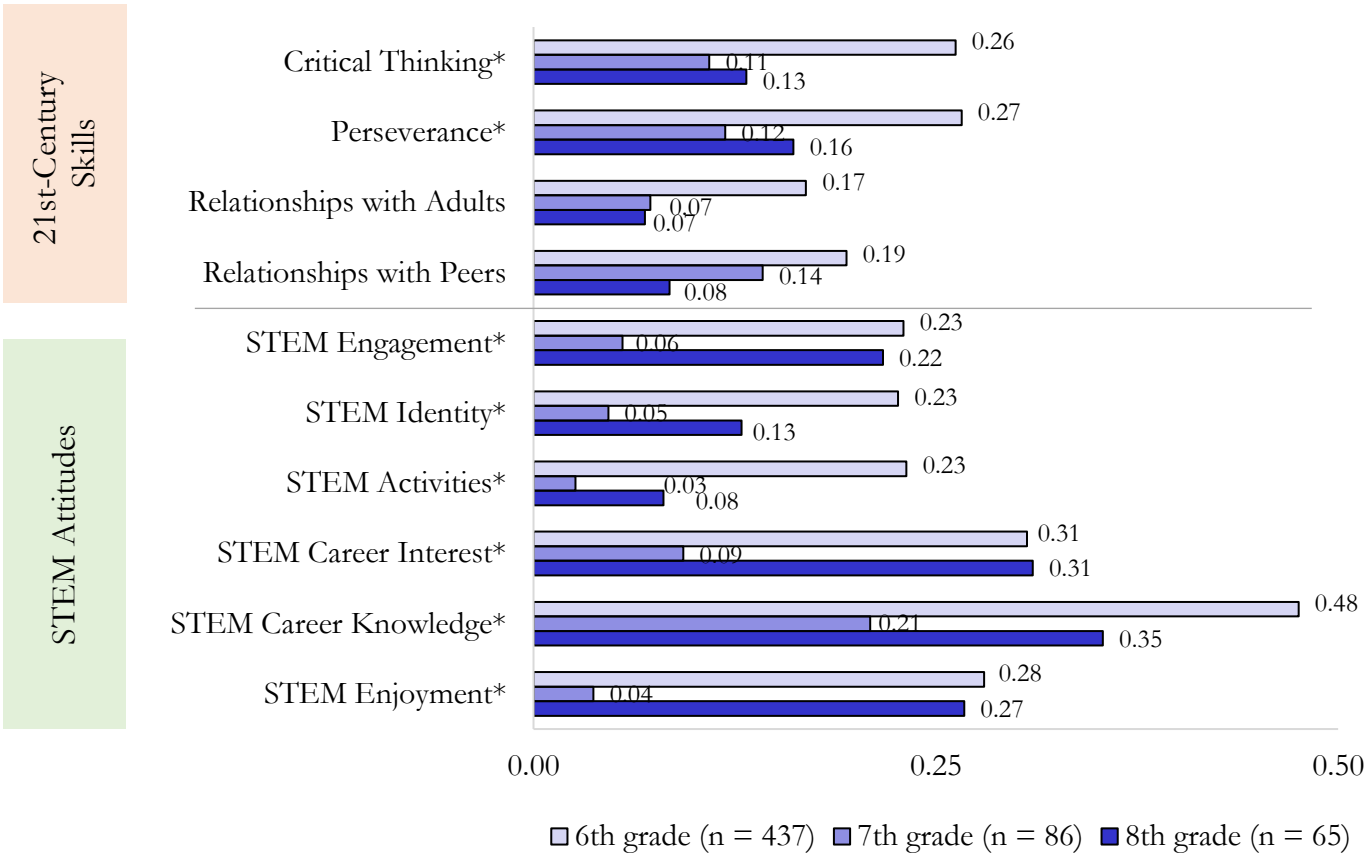
Between female students in 6th grade and female students in 4th-5th grade, there were no significant differences on any of the 6 scales. Between male students in 6th grade and male students in 4th-5th grade, there were significant difference on 4 of the 6 scales (*p*'s < 0.05). These scales were STEM identity, critical thinking, perseverance, and relationships with adults. Across all scales with significant differences, 6th grade male students reported greater increases than 4th-5th grade male students.

Figure 5. Significant Differences in CIS-S Outcomes between 4th-5th and 6th grade students (n = 1,064), Northeast Florida Regional STEM2 Hub, 2022-2023



Lastly, we examined differences in outcomes between 6th grade students, 7th grade students, and 8th grade students to better understand the longer-term effects of daily doses of STEM in 6th grade. Across 6th, 7th, and 8th grade students, there were significant differences on 8 of the 10 scales (*p*'s < 0.05) (**Figure 6**). These scales were STEM activities, STEM career interest, STEM career knowledge, STEM engagement, STEM enjoyment, STEM identity, critical thinking, and perseverance. Post hoc analyses revealed that across all statistically significant outcomes other than perseverance, 6th grade students reported significantly greater increases than 7th grade students.

Figure 6. Student-Reported Change in CIS-S Outcomes between 6th, 7th, and 8th grade students (n = 588), Northeast Florida Regional STEM2 Hub, 2022-2023



Educator Perceptions

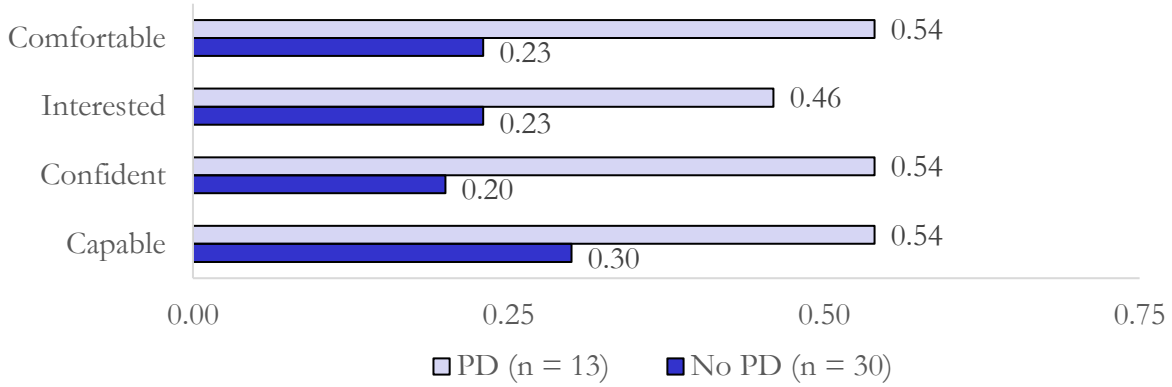
Between December 2022 and February 2023, 44 educators, representing 8 different Putnam County Schools completed the CIS-E survey. The primary role held by these educators was overwhelmingly Elementary (K-6) Classroom Teacher (68%), followed by not listed (14%), 6th Grade STEM Teacher (9%), K-5 STEM Resource Teacher (5%), and Secondary (7-12) Classroom Teacher (2%). The gender distribution of these educators skewed toward women (77%), with men comprising 20% of the sample. The largest race/ethnicity categories represented among these educators were White, Caucasian (83%) followed by Latino or Hispanic (7%) and prefer not to answer (7%). Two-thirds of educators (66%) held bachelor's degrees and over a quarter held master's degrees (27%). The largest percentage of educators (36%) had between 1 and 4 years of experience leading in-school STEM activities followed by no experience (16%) and 5 to 9 years (16%). Lastly, 68% of educators had either no experience or less than 1 year of experience leading out-of-school STEM activities.

When asked about their training and professional development, 68% of educators reported having no professional development within the last year. Of the 30% who reported receiving professional development within the last year, 46% said that they are "very comfortable" and 31% said they are "somewhat comfortable" instructing in the content area in which they received professional development. The remaining 23% reported feeling "very uncomfortable" instructing in the professional development content area. When asked "What kind of STEM training/support would you like to receive?" educators suggested "More Woz Ed trainings," "teaching biomimicry, more training with micro bits and data science," "new innovation workshops" and "cyber security." Additionally, multiple educators expressed a general interest in more professional development opportunities focused on expanding STEM knowledge or "Anything pertaining to K-5."

In addition to collecting data about educator characteristics, the CIS-E asks educators about their own STEM identities. On a scale of 1 to 4, educators' average STEM identity was 2.75. Educators whose primary role was STEM-specific (i.e., 6th grade STEM teachers and K-5 STEM resource teachers) reported significantly higher (p's < 0.05) average STEM identity scores than educators whose primary role was not STEM-specific (i.e., Elementary (K-6) Classroom Teacher and Secondary (7-12) Classroom Teacher). Additionally, educators who received professional development within the last year reported significantly higher (p's < 0.05) average STEM identity scores than educators who did not receive professional development within the last year.

Attitudes toward teaching STEM over time were also assessed with the CIS-E. Overall, educators reported significant positive change (p's < 0.05) in their attitudes towards leading STEM (i.e., feeling more comfortable, confident, interested in, and capable of teaching STEM at the time of the survey compared to a year prior). Between educators who received professional development within the last year and those who did not, there were no significant differences in feeling comfortable, confident, interested in, and capable of teaching STEM at the time of the survey compared to a year ago. However, while not statistically significant, educators who received professional development do seem to report more positive change than those who did not receive professional development (p's > 0.05) (**Figure 7**). Between educators whose role was STEM-specific and those whose role was not STEM specific, there were significant differences (p's < 0.05) in feelings of comfort teaching STEM such that STEM-specific teachers reported greater increases in comfort than non-STEM-specific teachers.

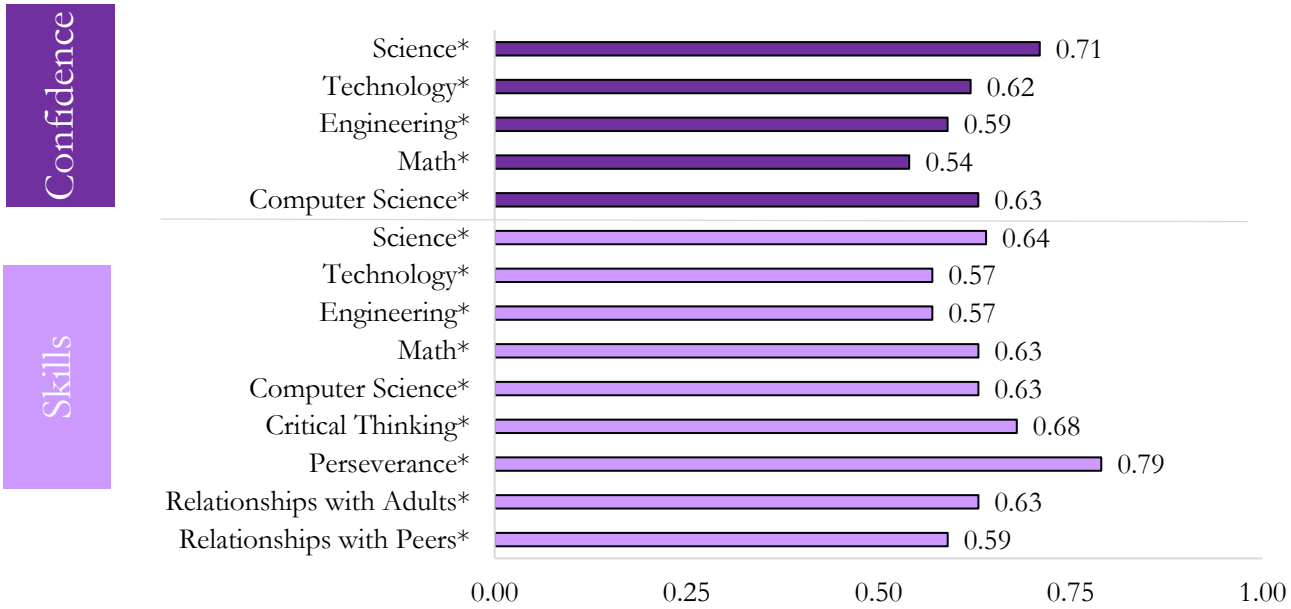
Figure 7. Average Difference Scores in Educators' Attitudes Toward Leading STEM by Professional Development (n = 43), Northeast Florida Regional STEM2 Hub, 2022-2023



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, on a 4-point scale from "Very Hard" to "Very Easy" (Shah et al., 2018). The two DoS-aligned practices with the highest ratings (i.e., teachers had the easiest time using these teaching practices) included "ensuring activities are inclusive of students from all backgrounds" and "ensuring all students actively participate in STEM activities."

Lastly, educators were asked to rate their perceptions of students' confidence and skills at two time points: before their participation in the STEM course and at the time of the survey. Analyses revealed statistically significant positive change in educator perception of students' confidence across all STEM domains, as well growth in students' skills related to STEM, computer science, and 21st-century learning (**Figure 8**).

Figure 8. Average Difference Scores in Educators' Perceptions of Students' Confidence Levels and Skills (n = 44), Northeast Florida Regional STEM2 Hub, 2022-2023



Summary

Northeast Florida Regional STEM2 Hub's student and educator data demonstrate how participation in in-school, progressively-aligned STEM courses in Putnam County Schools increases students' STEM-related attitudes and 21st-century skills. Students reported significant positive change on all 10 STEM and 21st-century outcomes, with the greatest positive change in STEM career knowledge and STEM career interest. Based on common effect size benchmarks, Putnam County STEM courses had a medium effect on career knowledge (Cohen, 2009). To contextualize this finding, the effect sizes of Putnam County student STEM career knowledge and STEM career interest were larger than the overall weighted average effect size found in a meta-analysis examining the impact of STEM programs on mathematics achievement (Siregar et al., 2019). Although Putnam County in-school STEM courses target all aspects of STEM, this comparison still highlights the magnitude of Putnam County STEM course impact.

Across multiple STEM and 21st-Century outcomes, analyses revealed outcome differences by gender and race/ethnicity groups. Specifically, females experienced significantly more positive change than males. Greater change in females may be partially explained by females reporting lower "baseline" (retro-pre) scores at the beginning of their STEM courses and therefore, having a greater threshold for change. Additionally, gender impacted the strength of the relationship between retro-pre and retro-post scores on a number of outcomes. Outcome differences between White, Caucasian (non-Hispanic) students and students of color may also be partially explained by White students reporting lower baseline scores on many outcomes.

Across all 10 STEM and 21st-century outcomes, students in 6th grade reported significantly greater positive change than students in other grades. Similarly, when we examined findings for 6th grade vs. 4th-5th grade students, 6th grade students reported significantly more positive change on both STEM outcomes assessed (STEM engagement and identity) and three of the four 21st-century skills (critical thinking, perseverance, and relationships with adults). Previous research found that more frequent engagement in scientific inquiry-based learning resulted in greater science proficiency (NAEP, 2019b). Because 6th graders participate in STEM as a core course that meets daily and students in other grades receive less frequent dosages of STEM learning, these differential outcomes may be explained by differences in dosage.

Educators reported significant increases in comfort, interest, confidence, and capability leading STEM activities at the time of the survey compared to a year ago. While educators who received professional development reported greater increases in attitudes toward teaching STEM over time than educators who did not receive professional development, those differences did not reach the level of statistical significance. Previous research has found that the effectiveness of professional development may be influenced by a variety of contextual factors (e.g., duration, format, alignment with curriculum, teacher practices and beliefs) (Lynch et al., 2019). To better understand the current finding, more information on the dosage, duration, and content of professional development received would be helpful, as well as a larger sample size to differentiate between the impact of STEM professional development on STEM-specific educators and non-STEM-specific educators.

Educators also reported increases in perceived student confidence in STEM, skills in STEM, and 21st-century skills, mirroring student-reported increases in all 10 STEM and 21st-century outcomes. Alignment between educator and student perspectives strengthens evidence of in-school STEM course impact and provides a more comprehensive understanding of the features of the learning environment that may be contributing to positive outcomes.

There were a few limitations to this year's data collection efforts. Sample sizes across grades were vastly differerent with this sample overwhelmingly representing elementary school students. Also, because of the small sample size of 6th grade STEM teachers, opportunities for analyzing outcomes for these teachers were limited. Future research should focus on collecting additional 6th grade STEM teacher data as well as linking educators with students to

better understand the experience of STEM learning within given classrooms. Because the first full year of Pathway STEM model implementation was 2021-2022, 8th-12th grade students in the current sample were not exposed to the Pathway STEM model during their younger years, making authentic comparisons across grades difficult. Finally, to further understand the STEM learning landscape of 7th-12th graders, we recommend conducting an assessment of the supply of STEM courses for 7th-12th graders in relation to the demand and examining differences between 7th-12th grade students who choose to take STEM as an elective and those who do not.

The Putnam County initiative to strengthen STEM learning and increase opportunities for high-quality STEM engagement is having a profound impact on student STEM and 21st-century outcomes. Through engaging students in STEM learning during the school day and supporting educators with professional development, Putnam County and Northeast Florida Regional STEM2 Hub are systematically increasing equitable access to STEM for all students, "challenging the status quo," and serving as an example of how school systems can play a key role in creating a strong STEM pipeline and future STEM workforce.

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Learn More

- Northeast Florida Regional STEM2 Hub website
- PEAR's website to learn more about our STEM tools and services

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