INDIANA DEPARTMENT OF EDUCATION

Indiana's Priorities for STEM Education

Executive Summary

Indiana’s Priorities for STEM Education seeks to develop a sustainable model for preparing educators to provide high-quality STEM learning opportunities by integrating the disciplines of science, technology, engineering, and mathematics to maximize student learning and achievement. This will be achieved through a collaborative process of professional development promoting research-based practices, ultimately resulting in providing students with an engaging STEM education experience that prepares them for emerging STEM careers and educational opportunities.

According to the Indiana Department of Workforce Development (Indiana DWD, 2021), the number of jobs in the computer and mathematical sector in Indiana are expected to grow to nearly 69,000 by 2028, an increase of approximately 7,000 from its 2018 base of 61,344 jobs. Indiana is prioritizing students to enter this workforce through the guiding principles of problem solving, access to STEM education, a focus on communication and collaboration, self-advocacy, and community partnerships.

Indiana has long-supported STEM programming and an emphasis on college- and career-readiness. Beginning in 2014, the Indiana Department of Education (IDOE) developed the STEM Certified Schools program, an effort to identify schools engaging in exemplary work related to STEM. 102 schools have earned STEM Certification to date. Beginning in 2018, the Indiana state legislature allocated funds to support a STEM grant program. Implementation of this grant focused on teacher training and the acquisition of high-quality curricula and other instructional resources.

As part of Indiana’s Priorities for STEM Education, Indiana will train and embed STEM instructional coaches into school corporations based on criteria identifying student populations of greatest need. Implementation of the coaching model will begin in Fall 2022, with ongoing research efforts aimed at ensuring the sustainability of this model long term. IDOE recognizes the continuum of STEM implementation that exists across Indiana and aims to support schools in working toward providing high-quality, research-based STEM education to students through the comprehensive implementation of resources and opportunities.

Note: The Indiana Department of Education developed this document in collaboration with Indiana educators and key stakeholders. It was informed by conversations with other external state agencies navigating STEM policy along with internal state agencies driving essential priorities for Indiana students.

Section 1: Introduction and Overview

“Imagine an education that includes solving hundreds of challenges over the course of the 13 years of schooling that lead to high school graduation – challenges that increase in difficulty as the children age... Children who are prepared for life in this way would be great problem solvers in the workplace, with the abilities and the can-do attitude that are needed to be competitive in the global economy. Even more important, they will be more rational human beings - people who are able to make wise judgments for their family, their community and their nation”. (National Research Council, 2014, p. 10-11).

Indiana’s Vision and Mission for STEM Education

Vision:

The Indiana Department of Education (IDOE) will collaborate with educators and schools across the state to implement Indiana’s Priorities for STEM Education in an effort to provide access to high-quality, integrated STEM instruction and to increase student participation and achievement related to integrated STEM learning opportunities. In a constantly evolving world, STEM education will prepare all students to contribute to society through innovative problem solving as the next generation of thinkers, creators, advocates, and entrepreneurs.

Mission:

Indiana’s Priorities for STEM Education seeks to develop a sustainable model for preparing educators to provide high-quality, integrated STEM learning opportunities to students, as well as support and provide resources to educators during implementation. This will be achieved through a collaborative process of professional development promoting research-based practices. These priorities will ultimately result in providing students with an engaging, integrated STEM education experience that prepares them for emerging STEM careers and educational opportunities.

STEM Education Defined:

Integrated STEM education is the purposeful integration of science, technology, engineering, and mathematics through an engaging and motivating, student-centered pedagogy and curriculum. Students are engaged in solving real-world problems using inquiry-based learning, problem-based learning, and engineering design practices, which require critical thinking and collaboration. Highly-trained and well-supported educators are key to providing these experiences to students.

The STEM Classroom works toward the integration of science, technology, engineering, and mathematics across content areas. Students pose questions when faced with real-world situations. Investigation, productive struggle, and innovation foster a culture of collaboration and creation. Students are partners in the teaching and learning process by developing skills to reason abstractly, model with science and mathematics, and justify their reasoning to express ideas precisely.

Problem solving is the engagement in a task for which the solution method is not known in advance (National Council of Teachers of Mathematics, 2013). The definition includes the willingness to engage with such situations in order to achieve one's potential as a constructive and reflective citizen (OECD, 2013). In the STEM classroom, methods of problem solving could include, but are not limited to, productive struggle, rich tasks, modeling, inquiry- and project-based learning.

Guiding Principles

When considering the scope and implementation of Indiana's Priorities for STEM Education, these guiding principles help to frame the reflection, research, and decisions that contributed to the development of these priorities. The following statements should be central to the implementation of this plan.

- Problem solving is an essential skill for lifelong success.
- Access to integrated STEM education, regardless of student background or demographics, is critical for creating future opportunities for empowered learners.
- Communication and collaboration are fundamental skills for engagement in an

innovation-driven society.

- STEM ignites the ability for individuals to learn and self-advocate.
- In order to provide and sustain a well-rounded STEM education, strong and cooperative community partnerships are crucial.

A Brief History of STEM Education at the National Level

The launch of the Russian satellite Sputnik in 1957 alarmed President Eisenhower so profoundly that he gave a speech calling on Americans to increase the number of scientists and mathematicians. A year later, the National Aeronautics and Space Administration (NASA) was formed. By the 1980s, these two events allowed the United States to become a world leader in the number of students attaining science and engineering degrees. In 1983, the Reagan administration produced a report called *A Nation at Risk,* which stated that science education should focus on more problem solving and critical thinking skills (United States Department of Education, 1983). In 1985, the year Halley’s Comet last passed by Earth, the American Association for the Advancement of Science created Project 2061 (the year we will next see Halley’s Comet), laying the groundwork for Science for All Americans and the Benchmarks for Science Literacy that are still used today (White, 2014).

The National Science Foundation (NSF) played a pivotal role in developing STEM education in the United States. In 1989, during the beginning of calls for interdisciplinary research, NSF launched the Small Grants for Exploratory Research program called Science, Mathematics, Engineering, and Technology (SMET).Over the last 15 years, U.S. presidents have elevated the importance of STEM through a variety of policy initiatives. Today, there is an increased focus on college- and career-readiness in STEM education. The release of the Next Generation Science Standards in April 2013, which are based on the Framework for K-12 for Science Education by the National Research Council of the National Academies of Science, included a new focus on integrating engineering into science classrooms (National Research Council, 2012; NGSS, 2014).

Prior Initiatives to Improve STEM Education in the State of Indiana

In 2014, IDOE developed the STEM Certified Schools program - an effort to identify schools engaging in exemplary work related to STEM education. This certification process recognizes schools that exemplify innovation by employing inquiry, project-based learning, community engagement, entrepreneurship, student-centered classrooms, and out-of-school STEM activities.The first cohort was certified in 2015, and today, a total of 102 schools have earned certification. More information about STEM Certified Schools can be found here.

STEM Certified Schools		
Year	**Cohort**	**Number**
2015	Cohort 1*	11
2016	Cohort 2*	7
2017	Cohort 3	11
2018	Cohort 4	27
2019	Cohort 5	18
2020	Cohort 6	14
2021	Cohort 7	14
Total Schools		102
**These cohorts have achieved recertification. Some additional schools were originally certified with these cohorts but did not progress through the recertification process.*		

In 2018, there was a one-time appropriation from the Indiana General Assembly to provide STEM grants, known as STEM Acceleration Grants, to schools to support local efforts. Beginning with the 2019 state biennial budget, funding for STEM Program Alignment became a regular line item at approximately $3 million per year, which allowed for the continuation of this STEM grant program. As a result, there have been five cohorts of STEM Acceleration Grants to date, totaling in excess of $6 million and positively impacting 117 districts. Implementation of these grants has focused on teacher training and the acquisition of high-quality curriculum and other instructional resources. An interactive map of STEM Acceleration Grant recipients can be found here.

STEM Acceleration Grants		
Cohort	**Number**	**Total Amount Awarded**
Cohort 1 (Spring 2018)	11	$953,249.00
Cohort 2 (Fall 2018)	14	$546,559.50
Cohort 3 (Fall 2019)	34	$2,053,531.81
Cohort 4 (Winter 2019/Spring 2020)	24	$1,090,738.91
Cohort 5 (Summer 2020)	34	$2,010,167.54
Total Districts & Awards	117	$6,654,246.76

Section 2: Review of Current Data and Academic Impact

This section explores a variety of data points that provide a high-level overview of STEM education in Indiana. The data illustrates the demand for high-quality STEM education and identifies the status of the STEM talent (including educator) pipeline, as well as student performance in STEM areas. This analysis defines the outcomes for four general research questions:

- What is the STEM workforce demand nationally and in Indiana?
- Historically, what does achievement in STEM pathways look like for Indiana students by population?
- What is the academic impact for students, specific to STEM, following the COVID-19 pandemic?
- What are the current trends in the licensure and preparation of educators to teach STEM?

STEM Education Research Questions

What is the STEM workforce demand nationally and in Indiana?

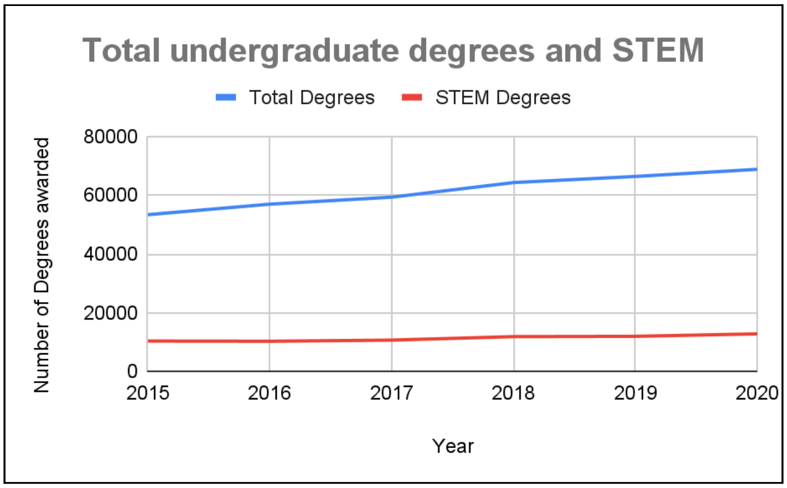
According to the United States Bureau of Labor Statistics Occupational Outlook Handbook (2021), employment in mathematics occupations is projected to grow 27% from 2019 to 2029. Employment in computer and information technology occupations is projected to grow 11% in the same period. Demand for these workers will be driven by greater emphasis on cloud computing, the collection and storage of big data, and information security. Employment in life, physical, and social science occupations is projected to grow five percent from 2019 to 2029. Increasing demand for expertise in the sciences, particularly in occupations involving biomedical research, psychology, energy management, and environmental protection, is projected to result in employment growth. In contrast, the Bureau of Labor Statistics projects 0.7% job growth per year overall between 2020 and 2030 (Dubina et al., 2021).

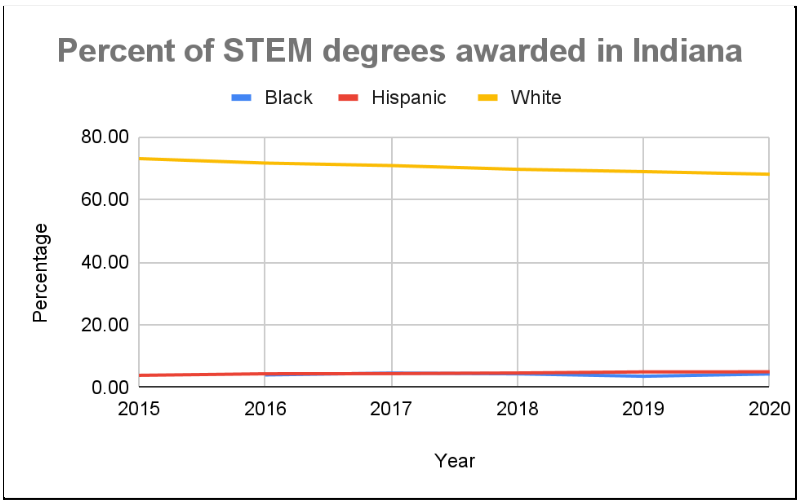
According to the Indiana Department of Workforce Development (Indiana DWD, 2021), the number of jobs in the computer and mathematical sector in Indiana are expected to grow to nearly 69,000 by 2028, an increase of approximately 7,000 from its 2018 base of 61,344 jobs. Jobs in architecture and engineering are expected to grow by 3,000 from its base of 52,382 in the same time period. Jobs in life, physical, and social sciences are projected to grow by 2,000 from its base of 20,267.

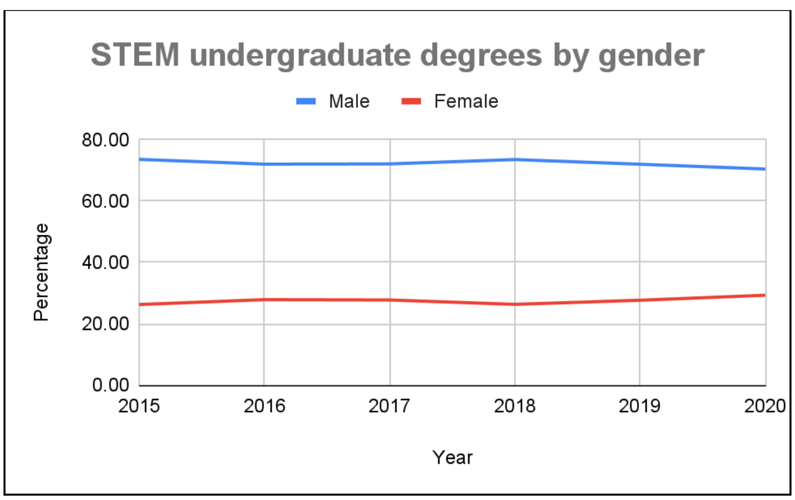
A 2020 study by McGunagle & Zizka highlighted employability gaps between what is taught in schools (kindergarten through grade 12 and higher education) and the skills valued by human resources professionals that employ within manufacturing and STEM fields, including critical thinking and problem solving. Given the current projections both nationally and within the state of Indiana, which identify the need for a skilled workforce, it is essential that Indiana builds a strong STEM talent pipeline.

Historically, what does achievement in STEM pathways look like for Indiana students by population?

Indiana students must engage in a thoughtful process as they make educational decisions that align with their goals for postsecondary educational and career attainment. These processes result in the development and pursuit of a pathway, and completion of a STEM pathway can lead to enrollment, employment, or enlistment in high-demand STEM areas. One of the pathways through which Hoosiers can acquire STEM jobs is by obtaining a college degree. The Indiana Commission for Higher Education (Indiana CHE, 2021) states that while the total number of undergraduate two- and four-year degrees in Indiana has been increasing since 2015, the number of STEM degrees awarded has remained relatively stagnant. Hispanic and Black students are awarded between three and five percent of all STEM degrees while comprising approximately six and nine percent of the Indiana population, respectively. There is also a large gender disparity in the number of STEM degrees awarded, with females receiving between 25-30% of all STEM degrees.


Total undergraduate degrees and STEM
Total Degrees
STEM Degrees
Number of Degrees awarded
80000
60000
40000
20000
0
2015
2016
2017
2018
2019
2020
Year


Percent of STEM degrees awarded in Indiana
Black
Hispanic
White
Percentage
80.00
60.00
40.00
20.00
0.00
2015
2016
2017
2018
2019
2020
Year


STEM undergraduate degrees by gender
Male
Female
Percentage
80.00
60.00
40.00
20.00
0.00
2015
2016
2017
2018
2019
2020
Year

What is the academic impact for students, specific to STEM, following the COVID-19 pandemic?

To better prepare Hoosier students for STEM jobs, Indiana kindergarten through grade 12 schools must prepare students for entry into those degree programs and careers. From 2019 to 2021, Indiana middle and high school course completion rates for most STEM courses were maintained within 85-95%. However, pass rates for these courses were between 70-85%, with some courses falling well below both of these statistics. There are also disparities in course completion and pass rates when disaggregated by ethnicity, socioeconomic status, special education status, English learner status, and gender.

Additional high school indicators of student performance in STEM include ISTEP+ Mathematics and ILEARN Biology End-of-Course Assessment (ECA) pass rates. In 2019, 35.3% of grade 10 students passed ISTEP+ Mathematics. Due to the COVID-19 pandemic, statewide assessments were not administered in 2020, meaning that the 2021 cohort was administered the ISTEP+ Mathematics assessment in grade 11 rather than grade 10. That cohort achieved a pass rate of 37.1%. An additional year of content exposure would typically result in a larger increase in proficiency than was observed. For the ILEARN Biology ECA in 2019, 38.6% of students reached proficiency compared to only 31.8% in 2021. There were also significant gaps when the data was disaggregated by ethnicity, socioeconomic status, special education status, and English learner status.

ISTEP+ Mathematics		
Student Population	**% Proficient 2019**	**% Proficient 2021**
All Students	35.30%	37.10%
American Indian	29.90%	30.30%
Asian	55.10%	60.60%
Black	12.10%	13.90%
Hispanic	20.40%	22.50%
Multiracial	29.50%	31.40%
Native Hawaiian or Other Pacific Islander	39.40%	36.40%

White	41.00%	42.50%
Paid Meals	46.80%	47.30%
Free/Reduced Price Meals	19.30%	20.30%
General Education	39.50%	41.40%
Special Education	7.70%	7.50%
Non-English Learner	36.60%	38.50%
English Learner	4.90%	4.80%
Female	36.30%	37.30%
Male	34.30%	36.90%

ILEARN Biology ECA		
Student Population	**% Proficient 2019**	**% Proficient 2021**
All Students	38.60%	31.80%
American Indian	32.90%	28.60%
Asian	55.70%	52.30%
Black	15.00%	11.10%
Hispanic	24.30%	18.90%
Multiracial	34.60%	26.90%
Native Hawaiian or Other Pacific Islander	39.20%	30.40%
White	44.40%	36.90%
Paid Meals	49.90%	41.00%
Free/Reduced Price Meals	23.40%	18.60%
General Education	42.40%	35.30%
Special Education	12.00%	9.10%
Non-English Learner	40.00%	33.00%
English Learner	5.30%	3.70%
Female	39.40%	31.40%
Male	37.80%	32.20%

ILEARN measures student achievement and growth according to Indiana Academic Standards. ILEARN is the summative accountability assessment in mathematics and English/language arts (ELA) for Indiana students in grade three through eight. The assessment was first administered in 2019; however, due to the COVID-19 pandemic, it was not administered in 2020. The assessment was again administered in 2021. The results of the Science assessment in grades four and six and the Mathematics assessments for grades three through eight are shown below.

ILEARN Grades 4 and 6 Science		
Student Population	**% Proficient 2019**	**% Proficient 2021**
American Indian	44.4%	32.7%
Asian	60.1%	47.5%
Black	18.9%	12.2%
Hispanic	30.5%	21.8%
Multiracial	41.9%	31.4%
Native Hawaiian or Other Pacific Islander	33.9%	23.6%
White	55.9%	45.5%
Paid Meals	62.8%	51.5%
Free/Reduced Price Meals	31.9%	22.6%
General Education	52.5%	41.7%
Special Education	19.6%	15.5%
Non-English Learner	49.8%	40.1%
English Learner	12.7%	8.9%
Female	47.3%	36.0%
Male	47.6%	38.9%

What are the current trends in the licensure and preparation of educators to teach STEM?

One pathway for college students interested in STEM subjects is to enter the teaching profession; however, there has been a decrease in the number of traditional undergraduate students majoring in subjects that lead to STEM teaching credentials. This has also led to a decrease in the number of teachers entering the profession certified to teach STEM disciplines.

There are different pathways available to individuals who wish to become STEM teachers, such as traditional undergraduate teacher preparation programs and Transition to Teaching programs. The number of individuals in Indiana receiving first-time initial practitioner certification from IDOE in STEM-related content areas and the number of license renewals and conversions in STEM areas have both decreased. This indicates that not only is the number of individuals becoming STEM teachers decreasing, but once they become certified, they are not converting their licenses and remaining in the profession.

First Initial Practitioner Licenses				
Content Area	**2016-17**	**2017-18**	**2018-19**	**2020-21**
Chemistry	64	51	49	37
Computer Education/Science	6	9	6	10
Earth/Space Science	17	18	9	12
Life Science	165	96	134	83
Mathematics	290	216	248	207
Physical Science	6	4	11	4
Physics	38	22	24	8
Technology Education	7	13	17	11
Total	**593**	**429**	**498**	**372**

Conversions to Proficient Practitioner				
Content Area	**2016-17**	**2017-18**	**2018-19**	**2020-21**
Chemistry	39	39	48	20
Computer Education/Science	16	8	11	5
Earth/Space Science	23	14	18	10
Life Science	106	99	130	42
Mathematics	208	209	250	139
Physical Science	7	6	9	7
Physics	19	17	18	9
Technology Education	17	18	13	6
Total	**435**	**410**	**497**	**238**

Problem Statements and Priorities for Indiana STEM Education

Based on the outcomes of the four general research questions explored above, IDOE identified three problem statements and priorities to support STEM education moving forward. These problem statements include:

1. Special education, English learner, Black, Hispanic, and economically-disadvantaged students perform below academic peers on mathematics and science assessments.

2. Historically, STEM disciplines have been taught as discrete content areas rather than in an integrated manner.

3. Students are not pursuing STEM coursework and pathways at the rates necessary to meet projected economic demands.

Therefore, IDOE recommends the following priorities to address these concerns:

1. *Refine STEM pedagogy with research-based best practices.*

The first strategy for increasing student achievement and retention in STEM is to refine

STEM instructional practices with a focus on integrating STEM content through research-based instructional practices such as inquiry-based learning, problem-based learning, and engineering design and modeling in mathematics and science. IDOE will encourage schools and districts to implement an integrated STEM pedagogy and curriculum that meets the needs of all students regardless of their background or demographics.

The academic impacts of the COVID-19 pandemic were significant for all Hoosier students in mathematics, but additionally deepened pre-pandemic disparities for English learners and Black, Hispanic, and special education students. Additionally, there are likely large deficits in science proficiency; however, specific academic impact in science has not been assessed. Indiana's response and action plan to these academic impacts is multi-year and intends to build local capacity to sustain meaningful and effective STEM education strategies. Through intentional professional development, curriculum planning, and interdisciplinary support, teachers will be able to create interdisciplinary STEM classrooms that work toward investigating and questioning the interrelated facets of the real world.

2. *Develop STEM leaders and educators.*

The second strategy includes a coaching model to support schools, which is further described in Section 4. Indiana's Priorities for STEM Education allows for parallel efforts within high-need schools and those desiring to utilize the training and support in STEM integration as a voluntary coalition. IDOE will consider factors such as state assessment performance, concentration of student populations such as special education, English learner, Black, Hispanic, and economically disadvantaged, and access to STEM education in determining schools of the highest need. IDOE will procure and oversee coaches to support a number of schools over a three-year period. These coaches will offer guidance and support in the implementation of research-based, integrated STEM content and pedagogy. For those engaging in the voluntary coalition, training of STEM coaches will also be made available for schools that are interested in using STEM coaching to support teachers in instruction grounded in integrated, standards-based content and problem/inquiry-based approaches to learning.

IDOE also recognizes the need for strong school and district leadership to support STEM implementation. To this end, resources and opportunities will be developed with the goal of supporting administrators as they guide the shift in school culture and pedagogical practices and build strong working relationships with the STEM coaches and educators. Recruitment, retention, and preparation strategies for STEM educators will also be considered to advance this work.

3. *Increase access to STEM courses, programs, and resources.*

A third strategy involves increasing access to STEM courses, programs, and resources for kindergarten through grade 12 students. Several student populations are traditionally underrepresented in STEM coursework, degree programs, and STEM fields, including female students and Black and Hispanic students (Indiana CHE, 2021). The academic impact of the COVID-19 pandemic further draws attention to the lower rates of participation and achievement. Underserved communities in rural and urban areas may also face barriers to progress in promoting integrated STEM education. Providing these student populations and communities with the necessary resources to be successful is a key part of this plan’s success. This is likely strengthened through key relationships with community, industry, and higher education partners.

Section 3: Research Supporting STEM Education

STEM education aims to develop a student's ability to think logically, solve problems, innovate in both academic and real-world contexts, engage in inquiry, collaborate with peers, and self-motivate (Committee on STEM Education, 2018). When explicit instruction does not make connections across STEM disciplines, isolated courses and coursework may prevent students from building necessary competencies and connections among the four STEM disciplines (Kelley & Knowles, 2016). Effective STEM education intentionally makes connections across subjects where appropriate. It requires a pedagogical shift in instruction that connects education to students' own interests and experiences and authentic problems within their communities (Kelley et al., 2021; Stohlmann et al., 2012). STEM education is also meant to provide all students opportunities to learn, develop, and acquire skills that will promote future success in college and careers (Doci et al., 2020; Estrada et al., 2016; Giuriceo & McLaughlin Jr., 2019; Saldutti, 2019; Toglia, 2013).

Inquiry-Based Learning

Inquiry-based teaching programs improve instruction and increase science and mathematics achievement by placing additional emphasis on fostering students' deep understanding and less emphasis on memorizing facts. Many science and mathematics curricula and instructional strategies for inquiry-based learning (IBL) have been proposed to enhance students' ability to investigate science phenomena (Liu et al. 2010). "Inquiry-based science is sometimes conflated with 'hands-on' science," says the Smithsonian Science Education Center. "While we know that actively engaging children with 'hands-on' science is important, it isn't enough. Inquiry-based science employs the diverse practices scientists use to study the natural world. A well-designed, inquiry-based curriculum is appropriate for all ages of learners and effectively teaches science content while developing scientific habits of mind at the same time" (Smithsonian Institute, 2015). The primary way in which inquiry-based instruction has been shown to increase student performance is through effective professional development for teachers

(Lai, 2018; Lee & Ensel Bailie, 2019; Leung, 2020; Liu et al., 2010; McGrath & Hughes, 2018).

Problem-Based Learning

Problem-based learning (PBL) is an instructional approach whereby students learn content by actively and collaboratively solving authentic, real-world problems. Used extensively in medical education since the 1970s, PBL has emerged as an exciting and effective alternative to traditional, lecture-based instruction in STEM education. Research shows that PBL improves student learning and retention, critical thinking and problem solving skills, teamwork, and the ability to apply knowledge in new situations – skills deemed critical for success in the 21st-century workplace. PBL challenges students to "learn how to learn" by collaboratively solving ill-defined, real-world problems. It is based on the constructivist model of learning and consists of four key components:

1. Ill-structured problems that are likely to generate multiple hypotheses about their cause and multiple approaches to their solution;
2. Student-centered learning, where students determine what it is they need to learn and find appropriate resources for information;
3. Teachers acting as facilitators or tutors; and
4. Authentic, real-world problems (Capraro & Slough, 2013; Sayary et al., 2015).

STEM Integration

The teaching of STEM through IBL and PBL has shown to have multiple benefits across the curriculum. A meta-analysis demonstrated that when PBL is the dominant strategy used, students' skills improved and their capability to compete with others in a knowledge-based society also increased (Mustafa et al., 2016). Additionally, PBL leverages productive struggle in the classroom. This leads to long-term gains and students who are better equipped to apply their learning in new situations (Kapur, 2010). Not all tasks are created with the same opportunities for student thinking and learning (Hiebert et al., 1998), and to ensure that students have the opportunity to engage in high-level thinking, teachers must regularly select and apply tasks that promote reasoning and problem solving (National Council of Teachers of Mathematics, 2014).

Integrated and interdisciplinary approaches to STEM instruction have shown to increase student learning across disciplines. Venegas-Thayer (2019) showed that when mathematics education was combined with music class, students had an increased understanding of both mathematics and musical concepts. In the same publication, two Australian initiatives that used an integrated STEM approach showed increased achievement in both mathematics and science (Doig et al., 2019). Students who learned computer programming were better able to transfer those skills to other academic tasks that conveyed creative thinking, mathematical skills, and metacognition. They showed increased achievement in both mathematics and literacy (Scherer et al., 2019). A study performed at Purdue University and Ivy Tech Community College by Kelley and colleagues (2021) has shown that integrated STEM instruction with a collaborative teacher model improves student learning outcomes better than studying each of the disciplines in isolation.

While teachers today know and understand the value of inquiry-based and problem-based learning, without proper training and support, they are more likely to revert to traditional instruction that is rooted in the work of the Harvard Committee of Ten (NEA, 1894), which placed an individual focus on subject areas. While discrete subjects are important, that focus challenges today's call for 21st century skills, critical thinking and application, and making interdisciplinary connections that industries desire (National Academies of Science & National Research Council, 2014).

The release of the Framework for K-12 Science Education by the National Research Council in 2012 and the subsequent Next Generation Science Standards (NGSS) released in 2014 reinforced the need for interdisciplinary connections through Crosscutting Concepts of Disciplinary Core Ideas. NGSS also focuses on building skills through the Science and Engineering Process Standards (SEPs) (National Research Council, 2012; NGSS, 2014).

Transitioning to Integrated STEM Programming

Transitioning to integrated STEM programming that serves all students requires a shift in school culture and in teaching practices (Meyers & Berkowicz, 2015). Educational leaders play an important role in initiating, fostering, and sustaining an integrated STEM culture through the collaborative engagement of school-community stakeholders and by supporting teachers in implementing integrated teaching practices. Integrating different disciplines within lessons, schedules, and planning teams requires collaborative skills and takes time to plan, facilitate, and effectively execute. STEM pedagogies (e.g., design practices, problem-based, inquiry-based, and experimentation) provide opportunities for educators and their students to learn and apply interdisciplinary concepts and practices. With support, educational leaders can be catalysts for the preparation of integrated STEM learning environments and curricular programming for kindergarten through grade 12 students (Akdere et al., 2019; Natarajan et al., 2021; Rangel, 2017; Suárez & Wright, 2019).

According to the U.S. Department of Education, STEM leaders have strong foundations in discipline-specific STEM knowledge and practices; however, school leaders of all backgrounds can be effective STEM leaders when they recognize the importance of STEM across the curriculum. Learning about disciplinary content, conducting activities in the disciplines (e.g., science research, use of emerging technology, engineering design cycles), and knowing the relevant kindergarten through grade 12 academic standards can all contribute to such foundations. To meet this need, which requires teachers and educational leaders to work across the traditional boundaries of individual disciplines in STEM, STEM leaders will need to:

- Develop strong collaboration skills; integrating STEM usually requires working with more people than are needed to teach a single discipline.
- Recognize who has knowledge about aspects of integrated STEM and can serve as a resource, rather than expecting to have all the answers oneself.
- Be open to collaborating with university, industry, and community partners, which are particularly important for authentic STEM learning experiences.

- Develop an understanding of how disciplinary ways of knowing and doing are similar and different across STEM contexts; negotiating these differences will be crucial in leading integrated STEM.
- Understand and respect the discourse of the disciplines; that is, understand what it means to investigate and document knowledge, as well as the standards for evidence within a discipline.
- Visit other STEM educational leaders to help identify commonalities about the challenges districts and teachers face and strategies they use as they work to provide integrated STEM education (U.S. Department of Education, 2021).

While coaching will be a critical component for developing in-service teacher capacity in STEM pedagogy, it is also necessary to increase the number of teachers entering the profession who are qualified to teach STEM content. Nationally, educator attrition rates average 16% annually. Attrition rates for educators entering the classroom without full preparation/certification are two to three times higher than for those who are fully prepared. As noted previously, Indiana has seen a decrease in the number of people obtaining teaching licenses that enable them to teach STEM content. Students in STEM fields often avoid teaching as a career option due to the availability of higher-paying jobs outside the classroom (Kumar, 2021).

State-level incentive programs exist to recruit teachers into science and mathematics classrooms. For example, the STEM Teacher Recruitment Fund was established by the Indiana General Assembly during the 2013 legislative session. The fund provides grants to high-performing organizations and programs working to increase the number of high-quality science, technology, engineering, and mathematics teachers in Indiana school corporations that are encountering shortages of qualified teachers and/or located in underserved areas.

To promote change and diversification within STEM fields, accurate data must first be collected. By tracking the number of degree candidates and earners in STEM disciplines across demographics, both the identification of institutions that are making progress and careful data-driven analysis of effective practices can occur (Estrada et al., 2016). In

2020, 12,854 postsecondary STEM degrees were awarded in Indiana, yet only 554 of those degrees were awarded to Black individuals, 822 were awarded to Asian individuals, and 643 were awarded to Hispanic or Latino individuals. As a whole, this amounts to just 16% of STEM degrees in Indiana. The gender gap is also prevalent within STEM degrees. In 2020, only 29.3% of the degrees awarded in STEM were given to females (Indiana CHE, 2020).

Section 4: Indiana's Plan for Support

Based on the data and research outlined throughout this document, Indiana has defined specific needs to support STEM education in the future . Most prominently, Indiana's Priorities for STEM Education highlights two parallel paths for implementation in the coming years.

First, a subset of schools will be identified to collaborate with IDOE to implement integrated STEM learning opportunities. This model intends for active participation by the school to ensure success. IDOE will collaborate with corporation and school leadership to identify a STEM coach and define their roles and responsibilities. IDOE will fund the associated salary and services of the coach, whose central duties will be training, oversight, modeling, and implementing the integration of STEM content and pedagogical practices. IDOE will consider factors such as state assessment performance, concentration of student populations such as special education, English learner, Black, Hispanic, and economically disadvantaged, and access to STEM education to determine schools of the highest need. Coaches and administrators will continually receive training and support over time, allowing collaboration across sites within Indiana. The coaches are intended to serve as leaders in receiving and disseminating information at the local level. IDOE expects significant training for coaches, school administration, and school staff beginning in the summer of 2022.

Secondly, IDOE intends to offer the same opportunities to additional cadres of instructional coaches beginning in the summer of 2022. Corporations and schools outside of the critical need defined above may opt-in as part of a voluntary coalition. Through this effort, minimum assurances and expectations will be defined for participation. Schools and corporations will be responsible for managing and overseeing implementation locally for this model. IDOE intends to provide collaboration and training opportunities at no cost for those participating in the voluntary coalition. Participation in this model will be capped annually to ensure diligence and oversight of the implementation by IDOE and at the local level.

Coaching Model

IDOE intends to utilize a coaching model for implementation. In schools, the purpose of coaching is to provide consistent, job-embedded support to teachers based on research-based practices. IDOE will provide transformational coaching to help teachers make appropriate pedagogical changes to improve STEM learning experiences and student outcomes. Additionally, IDOE seeks to facilitate instructional practices based on integrated STEM content and pedagogy. Research supports the effectiveness of coaching, and at its foundation, it has resulted in an "increase [of] the instructional capacity of schools and teachers, a known prerequisite for increasing learning" (Neufield & Roper, 2003, p. v). The growth in instructional capacity leading to increased learning is the ultimate goal for all schools. IDOE is excited to provide this support to Indiana schools that demonstrate the greatest need initially, with the long-term goal of building a model for all schools. Coaching's emphasis on teacher involvement, administrators, and ongoing professional development encourages program sustainability.

Research supports that the greatest benefit to coaching, as a form of professional development, is that the support is job-embedded and continuous (Darling-Hammond et al., 2017). When teachers receive consistent and relevant support that can be utilized specific to the needs of their students and themselves, they have a greater likelihood of implementing new instructional practices or carrying out new initiatives with fidelity. Mathematics coaches can positively influence beliefs about teaching and learning and also increase participation in non-coaching professional activities (Campbell & Malkus, 2011). Since Indiana's Priorities for STEM Education are rooted in the importance of STEM integration, they require that teachers are well trained, regularly supported, and continuously developed. Access to this type of support is the missing piece for the majority of teacher professional development. Providing a coach in high-need schools will give teachers a common source of guidance and information that is necessary for teachers to seek improvement and change. It will also support and encourage a community of professionals who continue to learn from each other.

In addition to coaching as a form of high-quality professional development, it also has proven to yield results for student achievement. In a study of student achievement before and after the implementation of a coaching model, "there was a significantly greater percentage of students scoring at proficiency and a significantly smaller percentage of students scoring at-risk in schools where coaches spent more time working with teachers" (Bean et al., 2010, p. 87). Specifically, Neufeld and Roper (2003) outline the positive improvements resulting from implementing a coaching model:

- Teacher development translates into classroom practice because the coach helps teachers implement what they have learned;
- A willingness among teachers to share their practice with one another and seek learning opportunities from their peers and coaches, and a willingness to assume collective responsibility for all of their students' learning;
- High-quality principal leadership of instructional improvement; and
- School cultures thrive when instruction is the primary focus of teacher and principal discussions and when achievement data drives instructional improvement.

Indiana's commitment to increasing access to STEM courses, programs, and resources is evident in recent parallel and complementary efforts that have been prioritized by the legislature including:

- Computer Science Coursework
- Math and Science Advanced Placement Opportunities
- STEM Grants
- Transitions Math Course

In addition, Indiana intends to continue and strengthen its STEM Certified Schools program, encouraging the growth and strengthening of STEM programs across the state and recognizing those that can serve as exemplars for others.

Supporting students is a critical priority for this work. While targeting efforts to those critically underserved allows for the greatest impact, IDOE also recognizes the continuum of implementation that exists across schools and corporations and aims to support all schools working toward providing high-quality, research-based STEM education to their students. Thank you for your partnership in the implementation of Indiana’s Priorities for STEM Education moving forward.

Section 5: References

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