Executive Summary

Opportunity Structures for Preparation and Inspiration (OSPrI):

A Logic Model that Describes and Explains Eight Exemplary STEM-focused High Schools with Diverse Student Populations[1]

The Opportunity Structures for Preparation and Inspiration (OSPrI) study sought to identify a set of common features, structures, and goals—called "critical components"—and common outcomes found in eight STEM-focused high schools with high rates of success and diverse student populations.

These inclusive STEM high schools (ISHSs) were selected for this NSF-funded study based on five criteria. The schools—

1) were nominated by experts in the field;
2) had diverse populations, including large proportions of students underrepresented in STEM fields;
3) self-identified as STEM schools and had curricula that exceeded minimum state or district STEM coursework requirements;
4) were schools of choice, either public or charter; and
5) had demonstrated outcomes in student achievement and other indicators of school success that substantially exceeded those of comparable schools, and for comparable student demographic groups.

The eight schools selected had populations of roughly 300 to 600 students. Most had been operating for 6-8 years old (the newest was four years old and the oldest had been in operation for more than 30 years). They had track records of success. While they had no direct contact or institutional affiliation with each other, they shared certain critical components and outcomes, the OSPrI study revealed.

A major goal of the study was to create an evidence-based logic model, or framework, that illustrates the workings of these eight exemplars and to explain how they functioned to achieve their successes in STEM, especially for students in underrepresented groups. This summary describes the critical components of the logic model, presented in a figure at the end of this summary.

In general, the evidence-based logic model shows how, over four years of high school, these schools provide structured opportunities for students to learn rigorous STEM content and process knowledge as they acquired familiarity and ease with STEM fields in their communities and the world of work. They came to understand STEM disciplines in context and develop career goals. This did not happen overnight; these schools provided students with choices and supports that helped them gradually develop "agency," or a self-conscious capacity to act productively. Research mentorships and experiences outside of school increased the depth and breadth of STEM knowledge through students' direct experiences, and all members of the learning community could benefit from an enhanced understanding of STEM within the school and its applications outside of school.

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Process for Developing a Logic Model

The first step in understanding how these exemplary inclusive STEM schools functioned was to identify an initial set of critical components, or design elements that would likely be essential to their success. In 2010, we reviewed the relevant scholarly literature in order to generate a list of the first 10 critical components, shown in Table 1 below. Next, we conducted site visits to each school and produced a thorough case study for each (see https://ospri.research.gwu.edu/) that focused on the design and implementation of each component. We found evidence for all 10 components in every school, but the prominence given to each particular component varied from school to school. For instance, a school with an early college high school curriculum (critical component 6) may have spent less time on project-based learning (PBL) than a school in which classes were taught solely through PBL (critical component 2), and vice versa. As we explored the evidence from the site visits further, new themes emerged that were important in describing and explaining how the schools functioned. We captured these by adding four "emergent" critical components, also shown in Table 1.

Table 1
10 Initial Critical Components (CCs)
1. College-prep, STEM-focused curriculum for all
2. Reformed instructional strategies and project-based learning
3. Integrated, innovative technology use
4. STEM-rich, informal experiences
5. Connections with business, industry, and the world of work
6. College-level coursework
7. Well-prepared STEM teachers and professionalized teaching staff
8. Inclusive STEM mission
9. Flexible and autonomous administration
10. Supports for underrepresented students
4 Emergent Critical Components (ECCs)
1. Dynamic assessment systems for continuous improvement
2. Innovative and responsive leadership
3. Positive school community and culture of high expectations for all
4. Student agency and choice

In early 2015, we created a first version, or Alpha version, of the logic model. In February 2015, we invited school leaders from each of the eight ISHSs in the study to a School Leadership Forum in Washington DC, where the researchers and school leaders discussed the model. The school leaders provided a helpful critique of this first version of the logic model. They were especially influential in refining elements of the model that dealt with impacts during high school for all students and made substantial additions to the end-of-high-school outcomes. Using the school leaders' feedback from this

Forum, we revised the model to create a second, or Beta, version of the logic model. This Beta version therefore reflects a consensus view of the ISHSs based on four years of research, including case study evidence, and the contributions of the leaders who ran the eight schools in the study.

Overview of the OSPrI Logic Model for ISHSs

The logic model addresses three main areas, summarized in rectangular columns in the figure at the end of the document:

1. **School critical components**, including both the initial and emergent critical components, categorized into four groups describing the schools' features: a) structure; b) what students learn; c) how students learn; and d) social dimension and purpose
2. **Impacts during high school for all students,** grouped by: a)what students know; b) what students can do; and c) who students become
3. **End-of-high-school outcomes**

There is strong research evidence for each of the school critical components derived directly from the eight cases studies, and substantial evidence from the case studies for the impacts during high school. For the end-of-high-school outcomes, the evidence comes primarily from the school principals themselves, who are best equipped to articulate the intended goals of their schools and for their students after high school graduation. Data from these schools show high rates of high school graduation and college admission. It is too soon to measure some of the longer-term goals for graduates of these schools. Each element is explained in more detail below.

School Critical Components

Structure

This category deals with the underlying school structures, approaches, and resources that build foundations for the ISHSs' operations. These structures are typically created as the school is planned and before it opens, and are maintained as the school grows and becomes an established fixture for STEM education in the community or school district. Among the ISHSs in this study, critical components related to structure included the following (parenthetical numbers refer to the list of critical components in Table 1):

- The schools, administration, and teachers were relatively autonomous from school district rules and practices (although they followed state-level requirements), and the administration was designed to adapt flexibly to the goals of the ISHS (CC9).
- Leadership was distributed among administrative and teaching staffs, both formally by assignment and informally through collaboration (ECC2). These leadership arrangements emphasized constant improvement informed by data from dynamic assessment systems. Typically, the schools had strong leadership and a "flat" hierarchy that shared responsibilities

and decision-making among the staff. To build support and buy-in, the leadership was guided by a vision based on some consensus from the community, the local school district(s) or state, and local business and industry and local institutions of higher education. This required a skilled and often visionary leader with a clear sense of the school's mission.

- The role of technology was considered early in the school planning process and eventually became the glue holding together an ambitious STEM program (CC3).

- The structure incorporated a system for transmitting feedback from students and teachers to leadership and back around. In the ISHSs studied, this included dynamic programs for assessment that enabled students, teachers, and often parents to check on students' progress (ECC1). The assessment system produced data that was useful for school improvement. The assessment system could deliver personalized feedback to help each student monitor personal progress. As discussed in the section on Social Dimension and Purpose, the assessments were accompanied by student supports that quickly and flexibly responded to student needs.

Together these components connected and facilitated communication among all members of the school and undergirded the other school components.

What Students Learn

The eight exemplary ISHSs provided students with a unique set of STEM learning opportunities to build STEM knowledge and skills, and STEM social capital to succeed in high school and beyond.

- Common across these schools was a rigorous STEM curriculum with required courses that exceeded state or district level course requirements and prepared all students for STEM college majors. Ability grouping was minimal; the same high baseline of curricular requirements applied to all students. STEM disciplines were often integrated with each other and with other disciplines in the humanities. Depending on the school's mission, students took engineering, career-technical education pathway courses, or technology courses (CC1).

- A huge bonus for many ISHS students included substantial opportunities to take early college STEM courses during the regular school day. Students were accelerated through the high school program of studies and then went on to accumulate college credits (CC6). This emphasis on early college coursework and dual credit programs reinforced the rigorous nature of the curriculum and provided educators, students, and families with immediate clear feedback on students' college readiness. School schedules were flexible and designed to provide opportunities for students to take classes at institutions of higher education or online. Families and students, many of whom were the first in their families to attend college, were well aware of the intellectual and financial value of such early college experiences. At some ISHSs, students could accumulate up to two years of college credits before graduating from high schools through agreements for credit transfer with the state university systems. In addition, these opportunities affirmed to students that they could be successful in college and find a place in campus life.

How Students Learn

These exemplary schools shared other components to facilitate high levels of STEM learning among their diverse student population.

- Each school had a carefully selected, high quality staff of STEM teachers (CC7) who were hired because they bought into and shared the school mission and vision. They had strong backgrounds in STEM disciplines, were collaborative, flexible, and willing to incorporate community resources and other innovative practices into their teaching.

- Teachers consistently encouraged students to be active, engaged learners (CC2) and often used a range of teaching and learning strategies, and production technologies to enhance and organize student learning. Teaching staff consistently emphasized students' responsibility for their own learning, through such practices as having students develop portfolios of their work, conduct research, work toward mastery, or demonstrate that they had met gateway requirements before moving on to more advanced learning opportunities. Teachers frequently used a range of instructional strategies, from PBL that called on students to produce or design a project, to more traditional instruction aimed at moving students quickly through graduation requirements so they could participate in learning opportunities outside high school.

- The schools studied often provided STEM mentorships, internships and research opportunities in business and industry and the world of work (CC5). These experiences not only made learning real and relevant to students, but also helped them to build social capital by interacting with a broad range of STEM professionals and to develop a more sophisticated view of STEM professions. Informal learning opportunities beyond the normal school day, week or year added to the richness of experiences (CC4); these included clubs and competitions, community service projects, and summer programs at local colleges and universities.

Social Dimension and Purpose

Several components identified in the ISHSs studied contributed to the social dimensions of learning and a shared sense of mission and purpose.

- The ISHSs in the study had a positive school culture that students and teachers described as "like family," perhaps all the more noteworthy because the schools were culturally, ethnically and socioeconomically diverse. Moreover, because they were schools of choice they were not usually "neighborhood" schools, so some students had to travel substantial distances to attend. Students shared a common shared commitment to learning that was not always found in neighborhood comprehensive schools. The ISHSs' expectations and learning opportunities applied to all students (ECC3).

- The schools often had an explicit mission (CC8) to create and nurture a diverse student body in STEM fields and encourage values such as persistence, grit, honesty and courage. Mission statements and goals were displayed and authentically reinforced by both educators and students.

- Because students entered these schools with different levels of competence and experiences in STEM, the schools provided systems of supports to enable all to succeed (CC10). This was especially crucial in schools with a mastery approach to learning. These supports ranged from easily accessible tutoring to personalized student advisories to summer bridge programs and careful placement in STEM programs in the community. In the final years of school, ISHSs often had full career and college counseling programs that resulted in virtually all students being admitted to college.

- Although these ISHSs were small and limited in course offerings compared to large comprehensive schools, they provided students with many choices about STEM opportunities both in the classroom and outside of school, accompanied by increasing personal responsibility. Students developed the agency to access supports for learning or STEM resources in the community during and beyond the school day. This emphasis on agency and choice broadened students' sense of belonging in the STEM community and widened their scope of possibilities (ECC4). The ISHSs deliberately nudged students to develop agency by placing before them opportunities such as career and college counseling programs (which in some schools were required courses) or early college or STEM research experiences. These opportunities were personalized, and families were involved these choices to support students' decisions.

Impacts During High School

The ISHSs in this study took a developmental approach, gradually introducing students to more rigorous STEM content, providing structured kinds of assistance to move students toward playing a more active role in the learning process, and intentionally and explicitly developing the traits, values, skills and knowledge needed to succeed in college and the world of work. This was done deliberately and thoughtfully at the eight ISHSs in this study.

What Students Know

The rich and challenging STEM learning opportunities provided by these schools were designed to enrich and expand students' interest in STEM and build their knowledge of STEM careers at the same time they developed strong STEM content and process knowledge. As students' interest and expertise in STEM fields grew, they gained a stronger sense of their capabilities in STEM. Many students at the schools we studied chose to attend for reasons other than the STEM focus, but the schools' focus strengthened these STEM capabilities for all students.

What Students Can Do

The ISHSs intentionally provided students with coursework and informal learning opportunities to build creativity, collaboration, and critical thinking and communication skills. The high standards and mastery systems allowed students to demonstrate academic achievements and other skills that would help them get into and succeed in college and the 21st century work environment.

Who Students Become

High school is a time when students form their identities. Students in these ISHSs could see themselves as "STEM capable" even if they did not intend to pursue a STEM college major. They were capable in mathematics and science, had experiences in design processes through engineering courses or career and technical education pathways, and were at ease using multiple technologies for learning and production. Students were "college savvy"; they had been carefully coached through the college admissions process and had often visited campuses for courses or other learning opportunities. These students from diverse backgrounds could see themselves as college-bound, and the college prep program developed their confidence. As students learned STEM in the community and business/industry contexts and worked with new technologies, they not only fostered their own agency but also collaborated in building STEM knowledge within the school. Students came to feel accountable to their school community and its mission of inclusiveness and the value of individual differences; this led to students feeling both empowered and accepted.

End of High School Outcomes

The ISHSs in this study all had high rates of graduation and college admissions—some approaching 100% annually. Some schools subscribed to the National Student Clearinghouse, which enabled them to track many of their students' paths after high school; their reports were positive, although comprehensive and valid reporting systems for STEM and other outcomes are elusive. While graduates of ISHSs may not choose a STEM college major, their high school preparation ensured that they were not shut out of one from a lack of the right preparatory courses. The school leaders reported that their schools had other post-secondary goals for their graduates—becoming responsible community members and global citizens who could use apply their STEM literacy to social and global issues. Because of their STEM backgrounds and common goal of graduating from college, ISHS students were positioned for upward social mobility, something they and their parents understood. A final intended outcome was for students to become lifelong learners, open to new ideas and able to contribute in a changing and sometimes uncertain world.

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School Critical Components

1. **Structure**
- Flexible & autonomous administration
- Innovative & responsive leadership
- Integrated, innovative technology
- Dynamic assessment systems for continuous improvement

2. **What Students Learn**
- College-prep, STEM-focused curriculum for all
- Early college-level coursework

3. **How Students Learn**
- Well-prepared STEM teachers and professionalized teaching staff
- Reform instructional strategies and integrated project-based learning
- STEM-rich, informal experiences
- Connections with business, industry and the world of work

4. **Social Dimension and Purpose**
- Positive school community and culture of high expectations for all
- Supports for underrepresented students
- Inclusive STEM mission
- Agency and choice

Impacts During HS for All Students

What Students Know
- Develop knowledge of and interest in STEM and STEM careers
- Cultivate deep STEM content and process knowledge

What Students Can Do
- Build creativity, collaboration, critical thinking and communication skills
- Demonstrate academic achievement
- Are prepared for post-secondary success

Who Students Become

Persons who:
- Self-identify as STEM capable
- Acquire college "savvy" and college aspirations
- Develop ownership of/agency for learning
- Are accountable to school community and mission
- Value individual differences
- Are empowered and accepted

End of HS Outcomes

Students are:
- Prepared for STEM in college
- Admitted to and complete college, especially 4 year college
- Engaged as responsible community members and as global citizens
- Able to apply STEM literacy to social and political issues
- Positioned for upward social mobility
- Lifelong learners