

STEM SCHOOL STUDY



The 8 Elements of Inclusive STEM High Schools

Findings from the
STEM School Study

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INTRODUCTION

WHAT DEFINES A STEM SCHOOL?

The STEM School Study (S3) team sat down with inclusive STEM school leaders from over 25 inclusive STEM schools and asked them to describe the parts of their schools that are essential to their school models. We found that while STEM schools vary in many ways, there are eight major Elements common to them all. Each Element is comprised of a number of components and together, they illustrate what STEM schools are and lay the groundwork for understanding how STEM schools work to achieve their goals.

The 8 Elements include six core Elements that we equate with the STEM schools' key educational goals:

- 1) Rigorous Learning;
- 2) Problem-Based Learning;
- 3) Personalization of Learning;
- 4) Career, Technology, and Life Skills;
- 5) School Community and Belonging; and
- 6) External Community.

The remaining two are supporting and contributing Elements:

- 7) Staff Foundations and
- 8) Essential Factors.

In this report, read about the 8 Elements, how we developed this framework, and how it can be useful to you. For additional information and findings, please visit our website at <http://www.outlier.uchicago.edu/S3>.

LaForce, M., Noble, E., King, H., Holt, S., & Century, J. (2014). The 8 Elements of Inclusive STEM High Schools. Chicago, IL: Outlier Research & Evaluation, CEMSE | The University of Chicago.



HOW TO USE THE ELEMENTS

If you are a practitioner at a non-STEM school who is interested in bringing STEM to your school or district...

As someone new to STEM, you might be asking yourself “What is a STEM school anyway?” Explore the Elements to see how STEM school leaders describe the components that are fundamental to meeting their educational goals. You can also explore how schools enact these Elements with the Infographic on the S3 website.

If you are a practitioner at a new or emerging STEM school...

In working with STEM schools across the country, we’ve found that while STEM schools often have different goals and focus, there are 8 common themes across them. The 8 Elements of STEM Schools can help give schools and leaders context for how they focus energy and resources. By exploring how components map onto these 8 Elements through the Infographic on the S3 website, practitioners at emerging STEM schools can reflect on their practices and strategies and the underlying educational goals they serve.

If you are a practitioner at an established STEM school...

Practitioners in established STEM schools may be confident in their school models after years of refinement. Leaders in these schools can use the 8 Elements and their components to articulate their school model to others. Additionally, like new and emerging STEM schools, established STEM schools can utilize the Elements for reflection and to consider how the current model components work together to achieve the STEM school’s goals.



PROBLEM-BASED LEARNING

The components of this element address the goal of problem and project-based learning. Examples include:

INTERDISCIPLINARY INSTRUCTION

Students identify ways that disciplines are interrelated, and how they reinforce and complement one another.

"PBL ties across the entire curriculum. It's integrated throughout everything we're doing in the whole day. When we designed the gaming platform, the English teacher said I'm going to work on prose and poetry... The product at the end was that they had to produce a prose to market their game on. In robotics unit, they had to do a lot of technical reading and writing. So that's what she focused on. And they had to write a technical manual."

STUDENT AUTONOMY

Students have independence in and ownership of their learning. Students set goals for their learning and make choices about how to accomplish them.

"The big thing is learner-centered education. It's one of the main components of our mission statement as well; that we really think students should be driving their own instruction. So that's kind of the basis where all of our problem-based learning, project-based learning comes from as well. We want self-discovery happening. Research, all research points to better-prepared students, better problem-solvers, from students who are able to address situations themselves, and solve problems themselves."

STUDENTS REFLECT ON THEIR LEARNING

Students consider the strengths and weaknesses of their learning approaches and ways they can improve them.

"We want a reflection built in. Students are metacognitive on the process. We figure out how it's going, how they can change and do better next time. This is a great process. It's built into the work they do in a daily basis."

OTHER PROBLEM-BASED LEARNING COMPONENTS:

Interdisciplinary Teams	Teacher Facilitation of Students Engaging in an Engineering Design Process
Intersession	Teacher Facilitation of Students Engaging with Real-World Content
Problem-Solving Projects	Students Cooperate and Work with One Another as Teams
Staff-Created Curriculum	Students Make Connections Between the Content They are Learning, the Real World, and Their Lives
Partners Support Instruction	
Teacher Facilitation of Teamwork and Collaboration Among Students	
Teacher Facilitation of Students Making Interdisciplinary Connections	
Teacher Facilitation of Student Interest They are Learning, the Real World, and Their Lives	



RIGOROUS LEARNING

The components of this element address rigorous and challenging learning, including cognitive demand.

REAL-WORLD CONTENT

Students make connections between what they are learning and real-world experiences, current events, and/or their daily lives.

"We want to see our learning environments across curriculum areas in authentic problems. Students are empowered to solve them because there are many solutions."

STAFF-CREATED CURRICULUM

Teachers and/or administrators create all or parts of the school's curriculum; this includes creating specific projects.

"We respect teachers as professionals. We let them use their data to create projects. I trust my teachers to cover standards in the way that they want. This takes teaching to another level. Projects become a teacher's hobby. Teachers are always thinking about projects."

STUDENTS REFLECT ON THEIR LEARNING

Students use thinking and process skills. This includes considering alternative arguments or explanations, making predictions, interpreting their experiences, analyzing data, explaining their reasoning, and supporting their conclusions with evidence.

"The habits are the first that come to mind. They were identified as work habits that anyone in the 21st century will be looking for in employees. Those habits should result in higher test scores. If you teach a kid how to think, the standards take care of themselves. The PBL model gets kids to dig deep- research, critical thinking, will this work?"

OTHER RIGOROUS LEARNING COMPONENTS:

- Core Course Sequence
- Mastery Learning
- Partners Support Instruction
- Teacher Facilitation of Students Making Interdisciplinary Connections
- Teacher Use of Assessment to Inform Instruction
- Students Make Interdisciplinary Connections
- Students Participate in Tutoring
- Students Participate in Early College Activities
- Students Take Risks



SCHOOL COMMUNITY AND BELONGING

The components of this element are central to school culture but are non-instructional.

STUDENTS TREAT EACH OTHER WITH TRUST AND RESPECT

Students have an established sense of trust with one another and exhibit respectful behavior.

“Culture is so important. We want them to respect themselves and others. We push this. It sinks in, and I see it when the freshmen come in and the older students complain that the new students don’t get the culture. We hope they leave with a desire to further their education and those 21st century skills.”

EXTRACURRICULAR ACTIVITIES

Students participate in sports and clubs that take place outside of regular school hours.

“We also encourage all of our students to be as involved as possible outside the classroom. So while we want our students to be successful academically, we understand that to create a holistic student that’s going to be successful beyond high school, that they need to be flexible, they need to be well rounded. So all of our teachers are asked to offer clubs or extra-curricular activities beyond school hours.”

STUDENT INDUCTION PROCESS

Program or activities that support new students’ transition to the school

“It’s for our incoming 9th grade students, students who will be new to our school. We run it for two weeks... We use it as an orientation time for our school, because our students come from every section of town... We want them to get to know each other a little bit so that when school starts, they’re not coming in as strangers. So they’ll know their classmates. We also use that time to go over the core values.”

OTHER SCHOOL COMMUNITY AND BELONGING COMPONENTS:

Small School and/or Classes

Student Access to School Throughout the Day

Teacher Facilitation of a Positive Social and Emotional Learning Environment

Staff Emphasizes Code of Behavior and Values

Staff Supports Needs of Whole Student

Students Contribute to School Decision-Making

Students Demonstrate Code of Behavior and Values



CAREER, TECHNOLOGY, AND LIFE SKILLS

The components of this element are related to the development of skills that students will use in future careers and life.

EARLY COLLEGE ACTIVITIES

Students participate in early college activities such as college courses.

"We try to incorporate college readiness standards throughout 9-12, doing activities that will help with our pathways. Students don't have to apply to be in a pathway, but we do have pathways that are outlined within our course descriptions that students can follow to make sure that they're preparing themselves for whatever course of study they may choose at the college level."

STUDENTS USE TECHNOLOGY

The teacher uses current and emerging technologies in instruction; students use technology as intended for learning purposes.

"Currently all of our students have personal laptops that run on Chrome. So they have access to that technology in every single one of their classes, without necessarily using it in every single one of their classes. But they have access. There are some classes of course that rely very heavily on their technology. There are other classes in which the technology acts as a resource and a support system for the curriculum."

STUDENTS USE WORKPLACE AND LIFE SKILLS

Students use the skills of communication, creativity, collaboration, leadership, critical thinking, and technological proficiency.

"All of our students do have to do presentations in all of their subject areas. One of the pieces of research that we found really interesting a couple years ago, is that a lot of students who graduate with really high abilities in science and math typically are very introverted, and they're not necessarily communicating with their peers as much as students who are not really focusing on those areas. So that's something that's really important to us as well... Because we live in a global society, so our students need to be able to communicate with all facets of that society."

OTHER CAREER, TECHNOLOGY, AND LIFE SKILLS COMPONENTS:

Instructional Themes	Students Cooperate and Work with One Another as Teams
Partners Support Instruction	Students Demonstrate Autonomy
Teacher Facilitation of Student Autonomy	Students Engage and Participate in Career Readiness
Teacher/Partner Facilitation of Students Engaging in Career-Readiness Activities	Students Engage and Participate in Service Learning
Teacher Facilitation of Students Learning Skills Specifically Related to the Workplace and Life	Students Participate in Demonstrations of Learning
Teacher Facilitation of Teamwork and Collaboration Among Students	Students Participate in Early College Activities
Teacher Models Use of New and Current Technologies	Students Participate in Higher Education Exposure Activities



PERSONALIZATION OF LEARNING

The components of this element center around the idea that learning should be customized for each student's ability and interests.

Examples include:

TEACHER DIFFERENTIATION OF INSTRUCTION BASED ON LEARNING NEEDS

The teacher customizes instruction based on ability, learning styles, and developmental levels of the students.

"Research, all research points to better-prepared students, better problem-solvers, from students who are able to address situations and solve problems themselves. So one of our big goals is to have as much learner-centered education going on as possible. Differentiation is huge for us; we want to make sure we're meeting the needs of all of our students regardless of their levels."

TEACHER FACILITATION OF STUDENT INTEREST

The teacher develops interest by relating students' lives and experiences to a lesson or unit. This also includes differentiation of the learning experience based on student interest.

"It's important that we build relationships with every student and family so we know what their interests are. The goal is to get kids to understand the world in which we live. I learned that students pay more attention to the world if they care".

TEACHER USE OF ASSESSMENT TO INFORM INSTRUCTION

The teacher uses information on current student understanding to inform and plan future instruction.

"We use a system in which our students are given diagnostic tests at the beginning of the year to see what their levels are. From that data we can then group the students according to their instructional level to really try to individualize their education a little bit more."

OTHER PERSONALIZATION OF LEARNING COMPONENTS:

Advisory	Staff Supports Needs of Whole Student
Small School and/or Classes	Students Engage and Participate in Career Readiness
Flexible Schedule	Students Demonstrate Autonomy
Student Access to School Throughout the Day	
Teacher/Partner Facilitation of Students Engaging in Career-Readiness Activities	
Teacher Facilitation of Student Autonomy	



EXTERNAL COMMUNITY

The components of this element reflect a connection between STEM schools and the broader and external community, from neighborhood to state level.

SCHOOL ESTABLISHES AND MAINTAINS A COMMUNITY PRESENCE

Staff creates and develops partnerships with organizations external to the school.

"The most important thing is our deep and enduring connection to our community. We do a lot of community involvement. We actually have people from STEM disciplines and beyond to work with kids and build ongoing professional and sustainable relationships. We want the STEM jobs in our community to be filled by people that come from our community. Community is definitely a general border- if people are willing to come here; they are part of our community. We will extend this invite to anyone who is willing to show up and work with students."

STUDENTS PARTICIPATE IN SERVICE LEARNING

Students participate in service learning or volunteer activities.

"We work very hard on community type of projects. For example, not just during the holidays, but you're going to hear -- well, all right, we're going to collect coats because -- they're collecting coats. Or "our students are going to do that." But we also do recycling. Right now, I don't know the exact count, but we have about -- I'm going to say near 30 students, let's say 25, 30 students, from our senior class, that have taken the accounting training where they are actually helping our community. They volunteer hours to help our -- they help our community people with their income tax."

STAFF SPREADS PRACTICES

Staff shares with others practices they enact in their classrooms and school.

"Two of our teachers are working with [another school], so they go over to teach those teachers about the project-based program. We're looking at expanding that next year... maybe even sharing one of our teachers throughout the year to go over and work with teachers over there... One of the best things that we can do is that we can share information."

OTHER EXTERNAL COMMUNITY COMPONENTS:

Staff Establishes and Maintains Partnerships

Partners Facilitate Spread of Practices

Partners Help Establish and Maintain Community Presence

Teacher Leaders Facilitate Communication Across Campuses



STAFF FOUNDATIONS

The components of this element enable and/or support desired school staff interactions and instructional behaviors.

STAFF COLLABORATE

Staff work through problems and develop ideas together.

“Brand new teachers are great. We can form their early teaching practices. We put new teachers with more experienced teachers. Our teachers are hardworking and good-natured. The teachers collaborate and support one another succeed.”

STAFF REFLECT ON WORK

Staff consider the strengths and weaknesses of their practices and ways they can improve them.

“It’s important that teachers are experts in data. Teachers determine their students’ needs. Then they build projects around students’ gaps. It’s good because you don’t have to rely on the central office. This does create a sense of ownership. We look at state assessments. And every 3 weeks teachers create a short 10-question assessment based on standards. We use this information. We run district assessments. We do formative assessment all the time in the classroom. We are also looking at student work- we are reflective as a staff on their work. We use this to reflect on our instruction, so we can help students be more successful.”

SCHOOL LEADERS FACILITATE STAFF GROWTH AND DEVELOPMENT

School leaders ensure that staff members have opportunities to grow in their roles as STEM school teachers and leaders.

“As a leader it’s important to understand what you’re asking teachers to do, and help facilitate project design and critical thinking things to help teachers create stronger practices and support students when they are struggling with things.”

OTHER STAFF FOUNDATIONS:

- Common Planning Time
- Individual Planning Time
- Non-Instructional Staff
- School Leaders Model Instructional Practice
- School Leaders Model and Support Risk-Taking and Autonomy for Staff
- Staff Engages in Relevant Professional Development/Growth Activities
- Staff Has a Sense of School Ownership
- Staff Participates in Decision Making
- Staff Treat One Another with Trust and Respect
- Staff Works with Autonomy



Essential Factors

The components of this element are environmental factors, staff attitudes, and other situations external to the school model itself that STEM school staff identify as essential.

STAFF ARE FLEXIBLE AND OPEN TO CHANGE

Staff are willing to engage in new practices and adjust what they do for the greatest benefit for students.

“Things do change and we change. We are able to morph the program as needed. We adapt as necessary. We have a flexible approach because the world has changed in the 4 years since we’ve been open. We want to stay on the leading edge to give them a world-class experience.”

REPRESENTATIVE POPULATIONS

School recruits and enrolls students with a focus on reflecting a population representative of the community/area the school serves.

“We aren’t a magnet- we take whoever we get. It wouldn’t be uncommon to hear a kid say that they hate technology. It’s our job to turn them on to it and expose them to it. You are better off as a result of exposing them. We do have those kids who are super geeked out and they create apps and stuff. We are just trying to turn people on if they are off and push them further if there are already into it.”

PROFESSIONAL DEVELOPMENT RESOURCES

Resources available to help teachers and staff develop and further their skills.

“We have a PD institute in the summer. It’s paid through our grant funds. We are looking to sustain that with other funds. It’s a 4-5 day PD that is led by teachers in facilitation with others as needed- Partners at the U of Washington. We have good support and researchers that help us with information.”

OTHER ESSENTIAL FACTORS:

- Family Involvement
- Online Management System
- Open Physical Space
- Regional School
- Partners Provide Money/Material Resources
- Standards
- Staff Believe All Students Can Learn
- Staff are Flexible and Open to Change
- STEM Instructional Leaders Support Instruction



WHERE IS THE S.T.E.M. IN STEM?

As you look through the eight Elements and the STEM school components, you may notice what seems like a lack of items that relate specifically to the S.T.E. and M. (science, technology, engineering, and math) disciplines. In our conversations with STEM school leaders and teachers, it has become increasingly evident that when they say STEM, they don't just mean these disciplinary subjects. When we ask about the missions and goals of their schools, most often they describe the importance of things like engaging students with real-world problems, preparing them for the workforce, and developing them as critical thinkers and active citizens.

The STEM disciplines themselves manifest in a variety of ways in the inclusive STEM high schools that participate in the S3 study. In some of the schools, the school model focuses heavily on STEM subjects, often providing more rigorous courses in science and math than what is required at the state level, and/or integration of engineering or technology courses. However, instructional practices and culture in these schools are often equally, if not more, important to their STEM identity. In many inclusive STEM high schools we work with, the STEM disciplinary focus is more subtle, and their self-identification as "STEM School" comes more directly from their focus on pedagogy and the school culture. In all cases, it is clear that some of the most valued components of STEM schools are not STEM-discipline specific, but relate to broader, transferrable, lifelong skills.

Many of the ideas and instructional approaches employed by STEM schools predate the STEM movement. Educational philosophers such as Dewey, Piaget, Vygotsky, and Bruner have advocated for inquiry and constructivist approaches for over a century. They argued for student autonomy, relevance, collaboration with peers, and learning-by-doing. They encouraged educators to view students as active participants in their own learning, and considered citizenship and creative and inventive thinking to be important student outcomes. None of them called it "STEM," but approaches and end-goals for students advocated by such philosophers are strikingly similar to what STEM school leaders mean when they talk about STEM today.

The STEM school Elements reflect these ideas, as identified by inclusive STEM school educators themselves: embracing problem- and project-based approaches; personalizing students' learning; creating a sense of community and family; equipping students with the skills necessary for college and for the workplace; and connecting with the community. STEM schools work to meet these goals through an integrated approach to learning and rigorous coursework in all disciplines.

Thus, while there may seem at first glance to be a lack of STEM discipline-related components in the S3 framework, this is a reflection of the broader definition of STEM that many school leaders have adopted. These schools certainly focus on giving their students high quality and challenging coursework in STEM subjects, but also in all of the disciplines they teach, and in the context of all of the other things they are working to accomplish. The STEM disciplines are there, but STEM is more than the sum of its S. T. E. and M. parts.



METHODS

The 8 S3 Elements emerged from four years of research with over 25 inclusive STEM high schools across the nation. This research took a “ground-up” approach in that rather than beginning with a definition of what we thought a STEM school should be, we asked the STEM schools to tell us what they are.

Outlier interviewed individuals in each STEM school to identify and describe the most important components, or building blocks, which contribute to the success of their school. We then coded the interviews establishing common themes, and identified 78 components. These components include structural components, such as specified time set aside for Advisory or cross-departmental collaboration, and behavioral components, such as students participating in early college activities or teachers facilitating a positive social and emotional learning environment. These components allow us to look at what STEM schools are and what they are doing in a very concrete, detailed, and measurable way—however, we also wanted to describe what STEM schools are more generally.

Working with the interview data and informed by appropriate literature, we organized the components into categories that emerged across the schools. Ultimately, these categories became the 8 Elements.

The Element descriptions, above, and the Infographic of the S3 STEM school components, found on the S3 website, illustrate the goals of inclusive STEM high schools, the contexts and conditions that support them, and the 78 components that comprise them. In the STEM School Study Roadmap Findings, also available at <http://www.outlier.uchicago.edu/S3>, we describe how we believe these components work together to achieve STEM school goals.