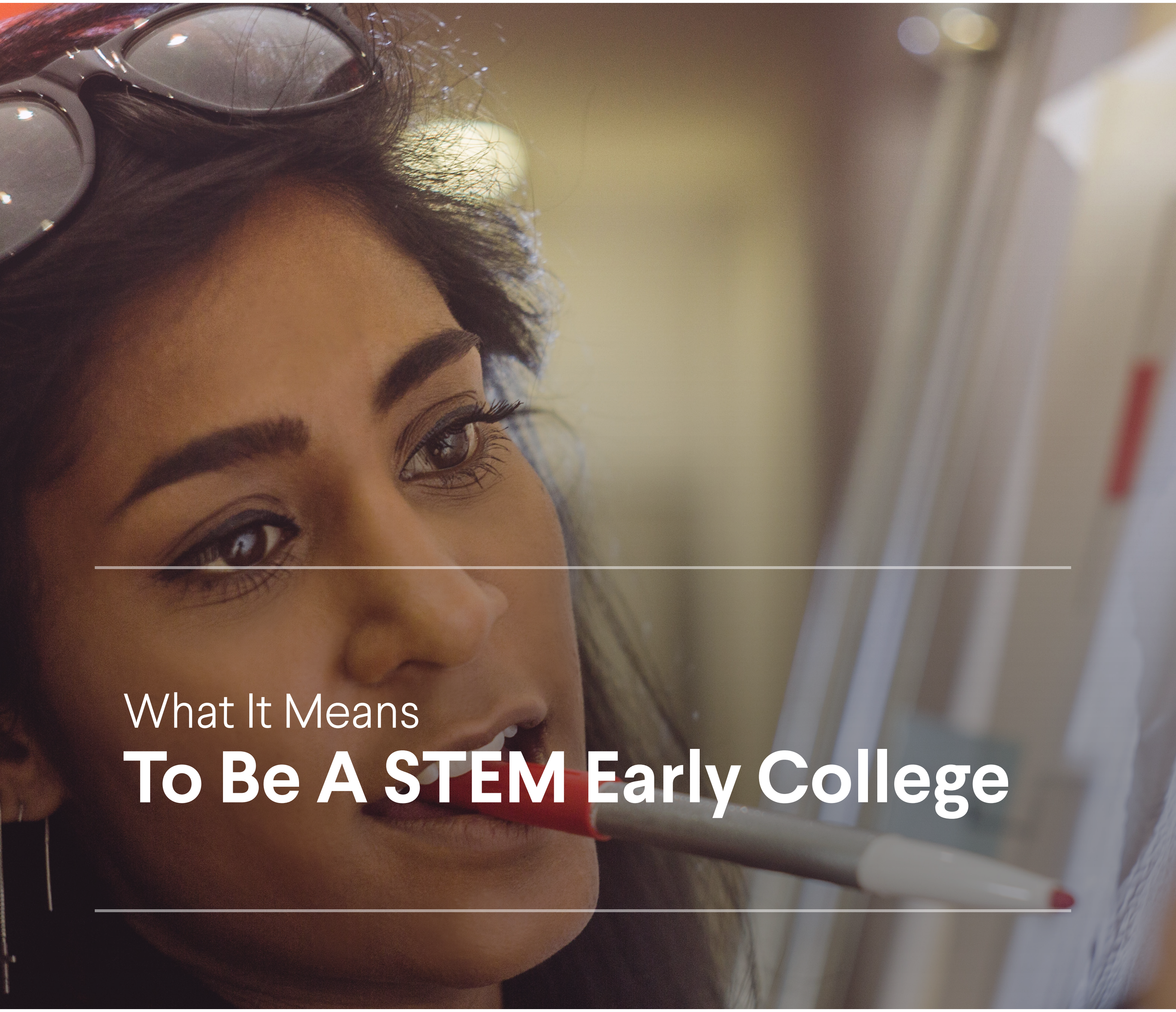
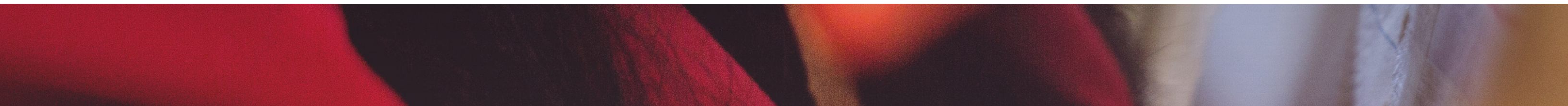


What It Means
To Be A STEM Early College

AUTHORS

Nina Arshavsky
Julie A. Edmunds
Karla C. Lewis
SERVE Center at the University of North Carolina at Greensboro



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About the Authors

Nina Arshavsky, Ph.D., is a Senior Research Specialist at the SERVE Center, with expertise in both STEM issues and early college. She led the qualitative data collection and analysis for SECEP.

Julie Edmunds, Ph.D., is Principal Investigator of the evaluation of the STEM Early College Expansion Program, (SECEP), as well as three other large-scale efforts to implement early college strategies in comprehensive high schools.

Karla Lewis, Ph.D., is a Project Director and Senior Research Specialist at the SERVE Center. She led the assessment of fidelity of implementation for SECEP.

SERVE Center
THE UNIVERSITY OF NORTH CAROLINA AT GREENSBORO

The SERVE Center at the University of North Carolina at Greensboro is a university-based research, development, dissemination, evaluation, and technical assistance center. Its mission is to support and promote teaching and learning excellence in the education community. Since its inception in 1990, SERVE has been awarded over $200 million in contracts and grants, including four consecutive contracts from the U.S. Department of Education for the Regional Educational Laboratory for the Southeast and four awards for the National Center for Homeless Education. SERVE is also a national leader in conducting research on the impact and implementation of early college efforts. **www.serve.org**

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SECEP
STEM Early College Expansion Partnership

The STEM Early College Expansion Partnership (SECEP) has been working in five districts in Michigan and Connecticut, helping them to implement the Early College model in local high schools while also strengthening STEM education. Over five years, SECEP sought to improve college readiness and STEM education experiences for 22,000 high need middle and high school students, decreasing drop-out rates and boosting college enrollment. The project's aim was to improve underrepresented populations' access to STEM careers by increasing the number of students enrolling in dual credit STEM courses and pursuing postsecondary credentials.

The project is led by the National Center for Restructuring Education, Schools and Teaching (NCREST) at Teachers College, Columbia University, in partnership with Jobs for the Future (JFF), the Middle College National Consortium (MCNC), and school districts and colleges in Connecticut and Michigan. We are achieving our goals by providing professional development and coaching that encourages school and their college partners to implement early college design principles as well as to improve STEM instruction.

Introduction

A STEM Early College is an innovative approach to redesigning high school that blends the Early College model, which has been shown to improve students' high school and postsecondary outcomes, with an emphasis on STEM. This brief explores the following questions: Why might districts and schools want to implement a STEM Early College model? What does the STEM Early College model look like when implemented in comprehensive schools? How could the implementation of the model be approached and supported? What are the outcomes for teachers and students?

This brief is based on data collected for the independent evaluation of the STEM Early College Expansion Partnership (SECEP) project, a federally-funded project led by Teachers College at Columbia University and their partners. The evaluation and this report were completed by the SERVE Center at the University of North Carolina at Greensboro.

Understanding STEM and Early College

What is STEM and Why is it Important?

The science, technology, engineering, and mathematics (STEM) workforce plays a key role in the growth and stability of the economy at both state and national levels. Job growth in STEM fields is three times faster than in other areas, and U.S. businesses voice a concern over the supply of qualified workers for those jobs, many of which remained unfilled even during times of high unemployment.[1] A number of recent national reports have called for improvement of K-12 STEM education in order to stimulate economic growth and to empower citizens to make informed individual and societal decisions as citizens and voters.[2]

Schools and districts have responded to these calls with various approaches to the improvement of STEM education.[3] For some, a focus on STEM means increasing the intensity and quality of an existing curriculum and approaches, increasing the number and level of courses, and increasing the time, resources, and expectations for learning in mathematics, science, and technology.[4] For others, STEM education means implementation of a project-based learning instructional approach that integrates all four STEM subjects to solve authentic problems or engineering tasks.[5] A third approach builds STEM education around career-related themes such as health or energy.[6] Two recent studies described the critical components of "inclusive STEM high schools", which are regular comprehensive schools with a STEM focus or schools that admit students on the basis of STEM interest rather than test scores or prior achievement.[7] Both studies determined that the critical components were (among others): rigorous STEM coursework and instruction, including project-based learning; college-level coursework;

A high-quality STEM education seeks to motivate and prepare students for productive careers in STEM fields by increasing the rigor of STEM coursework and instruction; incorporating project-based learning; expanding college level coursework in high school; and integrating innovative use of technology.

and integrated and innovative use of technology. Additionally, policymakers and colleges have begun looking at opportunities to build pathways (a sequence of high school and college courses) that lead towards credentials in STEM fields, particularly in those areas in need of workers.[8]

According to the National Research Council and to the Institute for Competitive Commerce, successful K-12 STEM education gives students more than content knowledge in math and science. Students prepared to pursue STEM-related and advanced STEM careers need to develop motivation, creativity, and interest in STEM subjects and careers, as well as the ability to apply STEM content knowledge and scientific inquiry to authentic or real-world problems.[9]

What is Early College and Why is it Important?

Early Colleges were developed to increase the number of students prepared for, enrolling in, and succeeding in postsecondary education. As originally conceptualized, Early Colleges were small schools focused purposefully on college readiness for all students. Frequently located on college campuses, Early Colleges targeted students who might face challenges in postsecondary education, including students who were the first in their family to go to college, economically disadvantaged students, English Language Learners, or students who were members of racial or ethnic groups underrepresented in college. The schools typically served students starting in 9th grade and the goal was to have students graduate in four or five years with a high school diploma and a postsecondary credential (usually an associate degree) or two years of transferable college credit. Supported by an investment by the Bill and Melinda Gates Foundation, the initial small-school Early College Model expanded across the country.

Rigorous, experimental studies have found that the model has had positive impacts on a variety of outcomes, including students staying in school, progressing in college-preparatory courses, graduating from high school, and enrolling in and graduating from college.[10]

Given the positive outcomes of Early Colleges, there have been efforts to move from the small school approach and implement the model in comprehensive high schools in order to serve a larger group of students.

Merging STEM and Early Colleges in Comprehensive High Schools

Many STEM-related careers will require students to receive at least some college education, which is why college-level coursework was listed among critical components of inclusive STEM high schools. To address the need for a workforce with college degrees in STEM areas, a number of small Early Colleges in the country have adopted a STEM focus.[11] Their successful experience provided foundational knowledge that permitted expanding these opportunities to a wider population of students in comprehensive schools.

A team led by the National Center for Restructuring Schools and Teaching (NCREST) at Teachers College at Columbia University sought to combine a STEM focus with the college readiness emphasis in the proven Early College model and created the STEM Early College Expansion Partnership (SECEP) to expand the model to comprehensive schools. The SECEP goal was to "improve STEM education for 22,000 high need middle and high school students, decreasing drop-out rates and boosting college enrollment [and to] improve underrepresented populations' access to STEM careers by increasing the number of students enrolling in dual credit STEM courses and pursuing postsecondary credentials" (SECEP Year 2 Management Plan). Additionally, the project aimed to increase students' interest in STEM subjects and careers by engaging students in STEM project-based learning. Funded by a five-year grant from the U.S. Department of Education, SECEP implemented a STEM early college model in comprehensive high schools in 10 districts in Michigan and Connecticut. The project also worked to support instructional change in middle schools in the two states. The SECEP partners included the districts, their partner colleges, and three intermediary organizations, who were guiding the implementation process and professional development: NCREST, the Middle College National Consortium (MCNC), and Jobs for the Future (JFF).

What Does a STEM Early College Look Like?

As defined by the project, the STEM Early College Model involved four Design Principles (see box). This brief focuses on the STEM College-Focused Academic Program Design Principle, which is the one in which STEM is most clearly embedded. This Design Principle articulated an ambitious goal of changing three key aspects of STEM education:

1. Increasing the rigor of the STEM curriculum and extending access to higher level courses to a broader range of students;
2. Changing instruction to incorporate STEM projects and technology; and
3. Creating STEM pathways leading towards some college credentials in STEM career areas.

As described in the Design Principles Self-Assessment Rubric, created by the project to facilitate schools' monitoring of progress towards their goals, each school aspired to implement the following specific actions:

a. Develop a clear approach for effective STEM education, led by the school's team, to guide decision making and be embedded in the school's annual plan.

STEM Early College Design Principles

STEM College-focused Academic Program, which emphasized early access to college courses, STEM pathways, student-centered and inquiry-based instructional strategies

Wraparound Student Supports, including academic and social supports and support for college knowledge

High school-College Partnership, a strong partnership with shared resources and regular communication

Culture of Continuous Improvement, including regular use of data and ongoing professional development and collaboration

b. Put systems in place to allow 90% of students to earn at least one college credit while in high school and create opportunities for the majority of students to earn 12 college credits.
c. Create 4-5 year pathways (academic plans) focused on STEM-related careers, spanning from the 8th grade through the first year of college, linked to available partner college majors, career certificates, and other credentials.
d. In mathematics and science classrooms, implement STEM college-preparatory standards-based curricula; implement instruction that reflects best practices in STEM education; and implement STEM projects aligned to STEM postsecondary education and careers.

To decide on their approach for effective STEM education, district and school staff had to learn about how STEM could fit into the early college model and had to decide on which instructional changes to prioritize. As they started working on the project, district and school staff reported realizing "...just how great the need is [for workers in the STEM fields]," and that they had learned "a lot about the STEM field, the careers and the opportunities in the STEM field, more than we ever knew." With the STEM Early College model being so new, there were few examples to draw upon in planning the implementation, and many district staff members and teachers noted that they would have liked to see models of STEM early college that were being done effectively in other comprehensive high schools. The next sections of this brief begin to meet this need by describing what the STEM components of this Design Principle looked like in action.

Designing STEM Pathways

Early colleges generally have an expectation that students take a sequence of high school and college courses—an academic plan or pathway—that lead to an associate degree or allow them to complete the general education requirements of a four-year institution. Under SECEP, these pathways were aligned to STEM areas and spanned from 8th grade to the end of high school, incorporating college courses. Partners developed pathways that focused on science, engineering, aviation, computer systems and construction technologies, robotics, culinary arts, advanced manufacturing, healthcare, and business. Especially popular were pathways focused on biomedical sciences, healthcare, and engineering. A sample pathway is provided on page 8 (note that the school name is a pseudonym).

The nature of the pathways created at each school depended on

1. The extent to which the schools had high school faculty with expertise in the content area who could serve as adjunct faculty to teach college courses,
2. Their alignment to programs or degrees offered at the partner college,
3. Local career demands, and
4. Students' interest in particular career fields.

Many pathways were designed to lead to a technical certificate as students in the participating schools were interested in these areas. One district had to replace an initially developed pathway in construction technology with another one in childcare because of the overwhelming student interest in the latter area. In both Connecticut and Michigan, pathways were implemented in comprehensive high schools participating in the project.

In Michigan, districts could also implement the pathways as part of Early/Middle College programs or schools. These programs or schools, based on the original Early College model, offer a fifth year of high school and are designed to provide students with early access to college courses such that they can graduate from high school with an associate degree or 60 transferable college credits. Early/Middle

Brown High School STEM Academy:
Five-Year Academic Plan

	Grade 9	Grade 10	Grade 11 STEM Academy	Grade 12 STEM Academy	Final Year STEM Academy @ College
English	English 9	English 10	College English 101 & 102	College Workplace communication	High School Math – Equal High School – Capstone High School - Seminar
Math	Algebra I or Geometry	Geometry or Algebra II	Geometry or Algebra II	College Personal Finance College Statistics	
Science	Biology is required and students can elect Principles of Biomedical Science or Intro to Engineering and Design as additional elective options	Physics or Applied Physics or AP Physics	Chemistry or elective science class	Chemistry or elective science class	**College-level** 24 Credits in a specific program of study CTE Articulation credits if applicable
Social Studies, History, and Government	World History/ Geography or AP World History	American History or AP U.S. History or numerous elective options	College PSY 111 College Econ 102 College Sociology 201	College Political Science College History College Econ	**List Below for Career Pathways Associate and Bachelor Degrees**
Physical Education	Strength or Team Sports/Health				
Language	Spanish 1 or 2 or French 1	Spanish 2 or French 2	College Speech 201	College Speech 202	
Elective	Computer applications + numerous HS elective options	VPA elective + numerous HS elective options	CTE or numerous elective options at AHS	CTE Numerous elective opportunities at AHS	
Seminar			STEM Academy	STEM Academy	
Other					
Total Credits	**HS: 7**	**HS: 7**	**HS: 0-4 CTE: 0-3 CC: 18 credits**	**HS: 0-4 CTE: 0-3 CC: 22 credits**	**HS: 1 CC: 24**

ENGINEERING/TECHNOLOGY PROGRAMS: Advanced Manufacturing Technology Agriculture Technology Architectural/Construction Technology, Civil Engineering, CNC Operator, Computer Aided Design, Construction Management, Electrical Engineering, Electronic Technology, Heating, Ventilation, Air Conditioning, and Refrigeration Technology Industrial Engineering Industrial Technology, Interior Design, Mechanical Engineering, Mechanical Technology, Photonics and Lasers Technology, Power Sports and Small Engine Technology Professional Pilot/Aviation Technology Service Management or Water Quality Technician Water Quality Management Welding

HEALTH SCIENCE PROGRAMS: Cardiac Sonography, Coding Specialist, Dental Assisting, Dental Hygiene, Diagnostic Medical Sonography (Ultrasound) Emergency Medical Technician—Basic Emergency Medical Technician—Advanced Emergency Medical Technician—Paramedic Emergency Services Management, Health Information Technology Health Navigator, Health Services Administration Hemodialysis Patient Care Technician Medical Assistant, Medical Insurance Specialist Medical Laboratory Technician Medical Office Administration Occupational Therapy Assistant Opticianry , Orthotic/Prosthetic Technology Pharmacy Technician Phlebotomy Technician Physical Therapist Assistant Polysomnographic Technology Pre-Occupational Therapy Radiation Therapy , Radiologic Technology Rehabilitation Studies Respiratory Care, Skilled Care Technician, Sterile Processing Technician Surgical Technology Therapeutic Massage, Vascular Ultrasound Technology Veterinary Technology , Occupational Therapy (MOT) , Nursing/PN, Nursing/ADN , Nursing/BSN Pre-Licensure or Nursing/BSN Post-Licensure (RN to BSN)

Colleges are implemented either as specific programs or academies that served a subset of students within a comprehensive high school or in stand-alone settings that might draw students from multiple high schools within an Intermediate School District (ISD).[12] At the conclusion of SECEP, all four participating ISDs in Michigan had Early/Middle College programs. Three of these programs had started as a result of SECEP, and one, which had started just a year before SECEP began, was further developed and enhanced due to the project.

In two ISDs, the Early/Middle College program was located in a Career and Technical Education (CTE) Center that served multiple high schools. In these cases, the district staff were working to integrate the Early/Middle College program with CTE. These blended programs still provided early college opportunities, such as earning transferable college credit towards an associate degree, but were more heavily focused on earning college credit towards career certificates. Participants found that pathways in CTE areas allowed a wider range of students to be served because they did not require students to pass college placement tests.

Across both states, the pathways were intended to start in middle school by encouraging enrollment in high school Algebra for eligible 8th graders and by creating STEM-oriented projects for all students (described in more depth below). One district started their pathways as early as elementary school through Project Lead the Way (PLTW), an engineering curriculum that focuses on hands-on projects exploring physical, life science, robotics, and engineering topics in the elementary school and technology in middle school.

Outcomes Related to Implementation of STEM Pathways

As a result of developing STEM pathways and other college credit options, there was an increase in the number of students earning at least one college credit while still in high school and in the number of college credits earned by students. A quasi-experimental study of the effort in Michigan found that SECEP students earned approximately double the number of college credits as students in comparison high schools (3.5 in SECEP vs 1.75 college credits earned in the 11th and 12th grades in comparison schools).[13] The same study also showed that by the end of the project, the exposure to college credit bearing courses was much higher in SECEP schools (30% of students earned at least one college credit) than in comparison schools (17.5% of students).

In a survey administered at the end of the project, 75% of staff members believed that “all staff in their school shared a goal of preparing students for STEM-focused postsecondary education or careers.” Additionally, 60% of administrators at the end of the project reported that over half of their students were enrolled in STEM pathways, while in the beginning of the project, only 28% of administrators did so. Similarly, a third of administrators at the end of the project reported that over 50% of their students were enrolled in STEM college level courses; this is in contrast to the beginning of the project, when only 7% of administrators said that.

Lessons Learned Related to Implementation of STEM Pathways

Staff at the districts and schools pointed to a few issues that should be considered during the design and implementation of STEM Early College pathways in comprehensive schools. First, schools had to carefully consider the specific pathways that they wanted to offer to ensure that students would be interested and would participate. Some STEM-related topics were not attractive to students and some schools had challenges recruiting sufficient number of students to fill college-level STEM pathway courses. One staff member noted that few students seemed to be interested in the STEM areas,

> “To me the bigger obstacle to the kids actually attending the early college is the fact that it’s STEM focused, because I think we have a lot of students who, if it was a general liberal arts type of look, we’d have more students that would be attracted to it but when we say it’s going to be medical or technical focused [they are less likely to participate].

One of the ways districts tried to overcome this challenge was to focus on STEM skills applicable to all topics and career areas, such as predicting and drawing conclusions using data, solving problems, analyzing relationships, and communicating their findings to others. Another solution was to blend the STEM Early College program with the CTE program, expanding access to college-level STEM courses to students interested in career certificates. For example, in one Michigan district, their STEM Early College was not initially attracting many students. Given that about half of high school students at the district were already enrolled in technical certificate programs at the Education Technology Center, the district blended the Early College with the Education Technology Center to enroll more students.

Another challenge was specific to rural districts, as their remoteness from any college and the lack of high school staff qualified to be certified as adjunct instructors prevented them from delivering college-level courses on the high school campus. Again, one of the solutions to this problem was to deliver college-level courses on the Education Technology Center campus, where students from multiple small rural schools came together to attend college classes.

Finally, districts and partner colleges recognized the need to make sure that pathways were aligned to four-year colleges and would include college-level courses that were transferable to multiple institutions and would not, as many articulated courses do, restrict students to attending the partner college to get the college credit.

Focus on STEM Curriculum and Instruction

The original Early College model had an emphasis on implementing instructional practices that support students' readiness for college by increasing the rigor of instruction. Under SECEP, instructional changes were focused on practices that increased rigor and also supported STEM learning, such as problem-solving, project-based learning and inquiry learning.

At the beginning of implementation, districts were guided through a process that helped them identify STEM instructional practices they wanted to emphasize. This process led to some differences in districts' approaches to STEM curriculum and instruction across the two states.

In Michigan, all districts elected to focus on project-based learning, with projects being implemented most often in math and science classrooms. Projects were introduced using a cohort-based approach. In the first year, all Michigan districts introduced cross-curricular STEM projects in the 8th grade, followed by 9th grade projects in the second year, and so on. As noted by one middle school teacher,

> We've been building each year and trying to add more...project-based lessons and inquiry lessons, more things where the kids are thinking their way through the projects instead of us just leading them or stuffing them with information.

Implementation of project-based learning included incorporation of increasing levels of rigor, inquiry, the engineering design process, and STEM-related critical thinking skills. As described by one teacher, "The [students] are starting to explore a little bit more, do projects that are related to integrating math and science, not just making them do the same old problems all the time."

The policy context in Michigan was supportive of the STEM instructional focus. Implementation of STEM Early Colleges coincided with pressure to implement the Common Core Standards in mathematics and the state-wide introduction of Next Generation Science Standards, which incorporate the engineering design process and inquiry-based learning. Some districts used this context to align various efforts to improve STEM instruction and curriculum, while in others they were perceived as separate burdens on teachers' time.

In Connecticut, the district put effort into math and science content and instruction, integrating technology into the science classrooms, and into project-based and inquiry learning strategies. The project supported professional development and coaching to help math and science teachers increase the rigor of instruction. In addition to an explicit focus on STEM instruction, teachers received extensive training in JFF's Common Instructional Framework, six student-centered and literacy-focused strategies designed to increase rigor and student engagement. In Michigan, it was predominantly math and science teachers who were engaged in instructional changes; this was the same with the Connecticut high schools. However, in the Connecticut middle schools, teachers of all subjects were encouraged to implement the Common Instructional Framework strategies. As conveyed by one teacher,

> What we're doing through the [SECEP] is we're teaching them certain strategies like collaborating, group work, writing to learn, things like that. In math, however, I'm using those strategies and I'm trying to get them their algebra skills earlier.

In addition to instructional change, districts across both states also attempted to increase student interest in STEM through afterschool clubs or teams in areas such as robotics. Four Michigan districts created a special period in the day for STEM curriculum focused on cross-curricular projects or robotics in middle and/or high and sometimes elementary schools. Some districts had additional grants to support the purchase of technology and to support STEM education, which were leveraged and aligned with SECEP project's goals.

Outcomes of the SECEP efforts in STEM Curriculum and Instruction

The focus on instructional strategies resulted in changes in classroom instruction across all districts, according to the staff surveys and interviews. Survey results showed overall positive changes over three years on the frequency of implementation of specific instructional practices measured by the Rigorous Instruction and Project-Based and Inquiry Learning scales, particularly in Michigan. Many teachers and administrators attributed the increased focus on STEM and changes in instruction to the SECEP project.

During interviews, participants also reported changes in STEM instruction, as well as in instruction in other subjects and commented on students' reactions to these changes. In the Connecticut district, teachers primarily reported changes in

"I go into a science classroom... in which I see students of all different levels. I've got some that greatly struggle, some that are high achieving. They're sitting in groups, they are working on white boards, the teacher has posted a friction example on the board and the students are diagramming it out, they're labeling, they're designing, they're doing different things and the discussions I'm seeing are phenomenal. I'm seeing students work together who never would have worked together in the past. I'm seeing students who weren't participating that are now holding quality discussions with their peers and volunteering and reporting out."

- Michigan Principal

instruction that related to the Common Instructional Framework rather than changes in specific STEM strategies such as inquiry or project-based learning. Teachers reflected that students were more engaged when the Common Instructional Framework strategies were integrated into the classroom, “I see a student that understood something and now is able to explain it maybe at a simpler level. That’s challenging. You understand something that’s complicated, and you can explain it at a simple level, that’s intelligence.”

Faculty from three of the Connecticut schools reported that student achievement was rising because of increased student engagement with the content. One teacher noted, “With the strategies and projects and making it more student-centered…it’s great to see those light bulbs go off because they discovered it. Then I’ve found that because they discovered it, they remember it.”

Across all schools in Michigan, teachers indicated that there had been increased development and use of project-based learning. One middle school made changes to the master schedule so that all 7th- and 8th-grade students spent the final two periods of the day (100 minutes) in project-based learning, where all teachers led groups of up to 18 students in six-week long inquiry projects. One teacher shared that this was the “biggest change” in the school, allowing teachers to work with smaller groups of students.

Similarly, staff in the high schools reported making changes in their instruction, also focusing more on problem- or project-based learning and inquiry. In one district,

the collaboration occurred across schools with the middle and high school staff working together on projects, which was unusual, according to one interviewee. A high school student described how a project helped them develop an understanding of physics concepts,

> We just did a chapter on simple machines, and we used levers and pulleys, and we're figuring out the force and how much work you end up actually doing with the use of those simple machines. And that really helped understand like, yeah, you're doing more work, but the work is easier.

A student in a different high school described how their environmental science class was almost entirely project-based,

> [The teacher] announces everything and then we get in the class, and then, from then on, it's free game for us. We have to figure it out. She gives us the resources but everything else is our minds and us being capable of doing it. And surprisingly, most of the students in that class are doing really well. Our assignments are very just, lab-oriented. Like, it's rarely that we sit down at our desk and do our assignments.

Interviewees from five different schools reported that the use of project-based learning led to increased student engagement and active learning in the classroom. High school students in one school noted that the use of more hands-on instruction had increased their interest in science. Six staff from two schools mentioned that the change in instruction was also leading to improved student behavior, with one school indicating that their number of suspensions had dramatically decreased.

While the specific instructional changes were somewhat different across the two states, their reported impact on teachers and students was similar: staff said that instruction became more rigorous and student-centered; staff also reported that this had resulted in more student engagement, improved student behavior, increased interest in science, and increased student achievement and content understanding.

Lessons Learned Related to Implementation of STEM Curriculum and Instruction

As with any instructional change, implementation of inquiry, project-based learning and other STEM-related strategies presented some challenges, including time, resources (including professional development), and logistics. All teachers mentioned that finding time to plan new lessons implementing STEM instruction was a challenge for them, "The difficulty is probably finding the time, and the planning time for it..." According to one district leader, schools needed to provide time to teachers for collaborative planning, "To sustain that long term, you have to have something built into your system for teachers to work together." Scheduling was a challenge for cross-curricular projects in some schools, because students did not necessarily share the same teachers.

While some teachers described large variations in student knowledge and skills as a challenge for implementing projects, other teachers believed that the openness of projects helped students at different learning levels: "I think that...having nice open tasks gives an entry point for all students. Then that means that even struggling students have that opportunity to kind of interject something. They have something that they can say."

Even though the Common Instructional Framework, inquiry, and project-based instructional strategies could be implemented in all subject areas, the "STEM" label scared many teachers away or made them feel that the initiative was not relevant to them. One project leader shared that a lesson learned was about the messaging, "...and I think that one of the things that we have to message is how is everyone is involved in this process and help the leaders provide that message to his or her staff also."

At the end of the project, a number of respondents predicted that the instructional strategies were likely to be sustained because teachers believed in their importance after seeing their benefits for students. As one district coordinator noted, "Those [teachers who are] really invested are seeing the benefits of the change. They would never go back to the old teaching methodology." At the same time, other leaders mentioned that, in the context of teacher turnover, it was important to continue ongoing training for these instructional strategies.

What Supports Does a STEM Early College Need?

Expanding implementation of the early college model into comprehensive high schools serving largely disadvantaged student populations while also integrating a focus on STEM is a massive undertaking. To aid schools in implementing the STEM Early College model, intermediary organizations (Teachers College, MCNC and JFF) provided a variety of supports to district leaders, schools and teachers. These supports included leadership coaching to district leaders, principals, and SECEP teams at the district and school levels for planning and leading implementation. Intermediary organizations provided one-on-one and group coaching to school, district, and college partners working together on a variety of issues that had to be addressed in the process of creating high school – college STEM pathways and improving STEM curriculum and instruction. There were also extensive professional development and networking opportunities for school teams, including their college partners. About a half of surveyed STEM teachers and almost two thirds of administrators at participating schools reported that they had received professional development or coaching over the life of the project.

As part of the SECEP project, district and college partners joined two major networks of early and middle colleges: the Middle College National Consortium (MCNC) and the Michigan Early/ Middle College Association (MEMCA). As members, the schools received opportunities to attend national and state conferences organized by these associations, attended workshops focused on the development of pathways, STEM instruction, and other relevant topics, and networked with and learned from other organizations engaged in the same work. These conferences provided venues for participants to talk and created conversations that could continue back at their schools.

To further support STEM instruction, the project partners provided and funded professional development workshops and instructional coaching in both states, both across and within the districts. In Michigan, the MCNC and MEMCA partners brought math and science consultants to lead a few three-day workshop series focused on best instructional practices in mathematics and science classrooms. These series were organized at the teachers' request. A teacher commented that the conferences exposed them to new topics:

> We got exposed to some new ideas that we hadn't even thought of. We've obviously been exposed to inquiry instruction in science. We were never exposed to growth mindset before. That started with instruction in New Jersey, then we've taken off here with our own. It's been very good and has made a difference.

This district then had the MCNC presenter come to the district and work with the whole math department. This format allowed the participants more time to process the information. The ISDs have also partnered with other organizations to provide STEM professional development for local districts. Mathematics and science coordinators at ISDs also provided professional development aligned with the project goals.

In Connecticut, in addition to a yearly district-wide summer STEM Institute, to improve STEM instruction, the district leaders identified a cohort of math and science teachers from all of the project schools to receive professional development from Teachers College instructors, focused on math and science content and instruction, integrating technology into the science classrooms, and on project-based and inquiry learning strategies.

In both states, instructional coaches worked with teachers to improve their instruction. But instructional coaching varied widely among different districts. In Connecticut, coaches focused on the Common Instructional Framework strategies with supplementary coaching provided on STEM topics. In Michigan, some districts hired full time math or science coaches who worked with math and science teachers on project-based learning and other strategies specific to their subjects. Other districts did not employ coaches, but relied on teacher leaders and principals, trained by the project, to disseminate practices they learned at the workshops organized by the project.

Some districts or schools deliberately used the strategy of developing a strong group of well-trained teacher leaders to sustain in-school instructional training beyond the life of the project and develop a teacher community of practice. The sustainability of in-school instructional training was especially important in the context of high teacher turnover. At the end of the project, staff in a small number of districts did express concern that the STEM instructional strategies would not be sustained in situations where there was high teacher turnover, low teacher buy-in, and a lack of sustained resources to continue teacher training and coaching in the new strategies.

As reported in the surveys and during the interviews, the majority of participants indicated that they valued the instruction-focused professional development, coaching, time for collaborative lesson planning, and online resources helping them to implement new instructional strategies. At the same time, school and district leaders expressed a need for additional professional development, coaching, resources and sufficient time for lesson planning around the new instructional strategies to help with implementation of STEM projects. That was particularly true for small districts, which had fewer funds for professional development and were not able to support many professional development opportunities for teachers.

Conclusions

The STEM Early College Model addresses a key educational need: increasing the number of students with strong STEM backgrounds who are also prepared for additional postsecondary education. The model does this by merging STEM practices with the proven early college model.

This brief summarizes how the STEM Early College Model was implemented in comprehensive high schools, describing the strategies used by schools and the supports needed to put those strategies in place. According to staff, these efforts resulted in increased student engagement, improved student behavior, increased interest in science and improvements in student achievement according to teachers and students. An increased number of students enrolled in STEM-focused pathways leading to STEM certificates or degrees.

Other schools wishing to improve STEM outcomes for students may consider implementing this model. Lessons learned from SECEP and presented in this brief can help schools more successfully move in this direction.

Endnotes

1 Hess, Kelly, & Meeks, 2011; Langdon, McKittrick, Beede, Khan, & Doms, 2011

2 Lacey & Wright, 2009; National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, 2007; National Research Council, 2011; President's Council of Advisors on Science and Technology, 2010.

3 Johnson, 2012; Leonard Gelfand Center, 2008; Robelen, 2011

4 National Research Council, 2011

5 Merrill, 2009

6 Ginsberg, Kinsey, & Zigarelli, 2011; Robelen, 2011

7 LaForce, et al., 2016; Peters-Burton, Lynch, Behrend, & Means, 2014

8 Rosenblum & Spence, 2015

9 Hess, Kelly, & Meeks, 2011

10 Berger et al., 2013; Edmunds, Bernstein, Unlu, Glennie, & Smith, 2013; Edmunds et al., 2012; Edmunds, Unlu, et al., 2017; Edmunds, Willse, Arshavsky, & Dallas, 2013

11 Arshavsky et al., 2014; North, 2011; Peters Burton, et al., 2014

12 An Intermediate School District or ISD in the state of Michigan is an education agency that provides support to a group of school districts and serves as a liaison between the districts and the state educational agency.

13 Edmunds et al., 2019

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88 Broad St., 8th Floor, Boston, MA 02110
122 C St., NW, Suite 280, Washington, DC 20001
505 14th St., Suite 340, Oakland, CA 94612
TEL 617.728.4446 **WEB** www.jff.org