Increasing the Number of Technical Experiences in a Comprehensive High School Lead to an Increase in Dual Enrollment at the Community College

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Abstract

In the coming years, there is expected to be a larger growth in STEM-related fields than non-STEM fields; however, public education is falling behind in preparing students for those future careers. In an effort to spark interest in the STEM field, local students and teachers were engaged in a wide range of STEM learning experiences. The goal was to determine if the creation of technical courses and technical modules in traditional courses would increase student interest in dual enrollment and post-secondary STEM education enrollment. Northwestern Community College in Winsted, Connecticut, was awarded a grant from the National Science Foundation as part of their *Engaging Students from Classrooms to Camps to College and Technical Careers* project. Working with students and teachers from the local public school, Torrington High School in Torrington, Connecticut, researchers provided teachers with support and professional development training, participation in industry experiences, as well as the materials and funds needed to implement technical courses and lessons in their classrooms. Students were provided an opportunity to conduct college biotechnological research in a college laboratory to help develop their skills and spark an interest in the field. When teachers who participated in the grant were interviewed, it was found that all of them viewed the experience positively, adding that it increased their knowledge and skill base as well as their confidence in preparing students for the STEM workforce. When students were interviewed about their experiences, they reflected upon their laboratory experiences as an advantage to their education as well as sparking interest in the STEM field. Dual enrollment numbers at Torrington High School have increased dramatically since 2018, when the grant was implemented. There has also been an increase in technical classes and dual enrollment classes being offered at the school. Providing public school teachers with support, funding, and the opportunity to have new learning experiences in their field has shown an increase in technical classes and dual enrollment classes offered at the school. There has also been a positive effect on their students, as there is an increased number of students enrolling in those classes.

Keywords: Technical, Dual Enrollment, Community College, High School

Introduction

There is a national need to increase the number of students prepared to enter the STEM workforce. According to the Bureau of Labor Statistics, the number of STEM jobs is expected to grow by 10.8% between now and 2032.[1] This equates to approximately 821,300 new STEM jobs.[2] This means that high schools and community colleges need to prepare more students to enter the STEM workforce.

Research studies show that "*Dual enrollment is a promising intervention to increase STEM career interest among all high school students, including students of different genders, races, socioeconomic status ….*"[3]

In 2018, Northwestern Connecticut Community College was awarded an Advanced Technology Education grant from the National Science Foundation to implement their *Engaging Students from Classrooms and Camps to College and Technical Careers* project with Torrington High School. The goal of this project was to increase student interest and capability to enter STEM programs and technical careers by building a pipeline from middle school to high school, on to college and into the workforce. This study examines the role that technical education played in increasing the number of students participating in dual enrollment programs and STEM education.

At the start of our project, Torrington High School (THS), located in Torrington, Connecticut was a school with low participation in dual enrollment programs. The school primarily serves socio-economically disadvantaged students with more than 60% of the student qualifying for free lunch.[4] While students at THS can earn college credits through AP classes or through dual enrollment classes with the community college or UCONN, and only seven students from the high school were enrolled in the dual enrollment courses at the community college.[5] None of the students of color or ESL students demonstrated college readiness or earned college credit through these AP classes or were enrolled in dual enrollment courses in 2018.[5]

Northwestern Connecticut Community College, which became Connecticut State Community College in July of 2023, is the smallest community college in Connecticut with an enrollment of about 900 students. The college offers STEM degrees in Technical Studies, Industrial Technology, Engineering Technology, Engineering Science, and Data Science as well as transfer degrees in Biology, Chemistry, Physics and Mathematics. High School juniors and seniors can take courses at the college for free through the High School Partnership program. They can also earn college credit by taking college level courses at high school. Both programs are considered dual enrollment programs.

Since research shows that dual enrollment "is a promising intervention to increase STEM career interest among all high school students, including students of different genders, races, socioeconomic status,"[3] we set out to increase the number of Torrington High School students participating in dual enrollment courses.

Research Question and Prediction

The research question that this study addresses is "will the creation of technical courses and technical modules in traditional courses increase the number of students earning college credit while in high school?"

The prediction was that if the high school developed more technical courses, then more students would enroll in the dual enrollment courses and pursue STEM programs at the college level.

The primary intervention that we use to increase the number students participating in dual enrollment courses what to increase the number of technical experiences that students were exposed to by increasing the number of technical courses and technical modules in existing courses offered at the high school.

Technical courses provide students with real world applications helping them connect their theoretical learning to technical careers. Technical courses and experiences not only help students make career connections, but they also excite students and enable them to be more confident in their knowledge and skills.

Methods

Professional Development for Teacher

Research has found that providing teachers with externship experiences provided teachers with a new perspective on workforce skills and results in an "*increased use of real world connections to help students see applications of course content in authentic employment contexts*."[6]

THS teachers participated in industry experiences, professional development training, and professional conferences. After participating in the externship, training or conference, teachers developed a lesson plan based on their experience. Upon submission of lesson plan they were provided with the materials needed to develop and implement the lesson.

THS teachers participated in summer externships for one to two weeks at the following companies:

- Becton Dickinson, a global medical device manufacturing company. During the externship teachers had a tour of the manufacturing plant and worked in the microbiology and quality control laboratory.
- Wittman Battenfeld, global produced of injection molding robotics in the engineering department. During the externship teachers toured all departments in the company and
- Dymax Corporation, a manufacturer of light-curable adhesives. During the externship teachers toured all departments in the company and worked in the research and development department.

They also attended the following professional development workshops and conferences:

- High Impact Technology Conference
- Advanced Technology Education PI Conference.
- STEM Guitar Build workshop
- BioCore Skills Institute
- National Association of Science Teachers
- Timber Framers Guild: Heartwood School

The impact that these experiences had on the teachers was evaluated through a survey developed by the project's external evaluator. The survey asked the participants to rate their agreement with three statements:

As a result of this experience:

- *"I am more likely to engage in discussions related to STEM Technical Careers and preparation for the workforce.*
- *"I am more attentive to developments about STEM Technical Careers especially in our community."*
- *"I am more likely to engage in conversations with my administration about increasing education and career opportunities and pathways in STEM for our students."*

The survey also asked them to provide a summary of the impact of the experience.

The high school course catalog was used to confirm the number of technical courses offered at the high school each year. Teachers self-reported on the inclusion of the technical modules in their courses.

Experience STEM DAY for High School Teacher and Students

High School teachers also brought their classes to the college for Experience STEM Days. During these days the students participated in a classroom activity designed and run by community college STEM faculty. We offered Experience STEM Days with focuses on Engineering, Natural Resources, Data Science, Biotechnology and Chemistry. During these days, high school students experienced a class taught by college faculty, were provided with lunch during which they listened to a presentation about technical careers and local STEM-based companies. The high school teachers met with the college faculty and learned about the industry connections and research opportunities that are available to the college students. During the pandemic, college faculty and industry representatives produced videos that the high school teachers shared with their students.

Table 1. Student Participation in Experience STEM College Program

Academic Year	#of THS Students who attended the Experience STEM College Program/STEM Career Days	# of High School Teachers who attended the Experience STEM College Program/STEM Career Days
2018-2019	366	10
2019-2020	30	2
2020-2021	139 (virtual)	NA
2021-2022	324(126 in-person and 198 virtual)	8 (in-person)
Total	**859**	**20**

Attendance was taken at the events or by the teachers for the students watching the videos. After participating in the experience, students completed a survey. The survey was developed by the external grant evaluator and asked students to rate their agreement with a series of questions and to provide comments on their experience. The list of participants was also sent to the Torrington School District Grant Coordinator who provided data on student demographics.

Dual Enrollment Data Collection Process

The college's Institutional Research office provided data on the number and demographics of the Torrington High School students participating in the dual enrollment programs. Students provide demographic data when they complete the registration form for the program. The community college offers two dual enrollment programs where high school students earn college credits. The first is the High School Partnership program where high school students attend classes at the college and the second is the dual enrollment program where high school students earn college credit for courses taken at the high school.

Community College Enrollment and Demographic Data Collection Process

The college's Institutional Research office provided data on the number and demographics of the college students enrolled in STEM programs. Students provide demographic data when they complete the registration form for the college.

Data Collection Process for (the College Readiness of the High School Students

Data from Connecticut's Department of Education, as published on their Education Insight's website was used to obtain the "College Readiness" data. College Readiness, as defined by Connecticut's Department of Education, means that a student has earned 3 or more college level credits or a 3 or higher on AP or ACT tests.

Results

Impact on Teachers

When we asked the high school STEM teachers who participated in the project about the impact that participating in the project has on their teaching, 100% strongly agreed each of the following the statements:

- *"I am more likely to engage in discussions related to STEM Technical Careers and preparation for the workforce.*
- *"I am more attentive to developments about STEM Technical Careers especially in our community."*
- *"I am more likely to engage in conversations with my administration about increasing education and career opportunities and pathways in STEM for our students."*

The teachers also provide the following testimonies:

- *"I am now capable of using the CNC machine at Torrington High School. We actually discovered that we had to make significant repairs to the CNC machine which helped me better understand the components. I am also able to use the design software to create shapes that can be carved on the CNC machine. This includes guitar bodies as well as other projects such as signs, and inlays. This will help prepare students for a branch of design and manufacturing that I was otherwise far less qualified to teach." Technology Teacher*

- *"I feel that I am far better equipped to marry several academic disciplines when building guitars in the wood shop. I participated in the STEM Guitar Workshop with three of my colleagues from different academic departments. We had one representative from each of the following departments: Math, Science, Technology Education. Each teacher visualized teaching academic content to students from different angles as they relate to the different disciplines. The lessons in physics, geometry, electronics, soldering, manufacturing, wood technology are undeniable. I will collaborate with these teachers to help the students appreciate the interdisciplinary nature of building something like a guitar." Technology Teacher*

- *"Being involved with the project has allowed me access to the industry in which my students could potentially be involved with. I now have the knowledge to be able to better prepare them. I am more aware of skills my students will need when entering university or industry and allows me to better prepare them with the appropriate laboratory skills which will enhance their education in STEM or in their STEM career. I have been able to develop several engaging lab activities to help students hone these skills and can now teach these skills with more confidence to my students, I have seen increased engagement in students during class as well as outside of*

class. I have implemented several engaging and exciting activities to teach and help students practice these skills. This has resulted in a high demand for the Biotechnology class in the school." Biotechnology Teacher

- *"Wittman-Battenfeld is a company that manufactures plastic injection molding machines and robots that work with the molding machines to handle parts into and out of the molds. The company has also developed a robot programming system that is user-friendly and can be used by technicians in industry (who may not be proficient with computer coding) to program the robots. Companies who use Wittman's robots are able to teach mold operators to program the robots for precise functions that speed up the production process. During the course of our externship, we were able to program a Wittman robot to perform a series of movements that simulated handling of parts into or out of a molding machine. While we could not obtain robots identical to those used in industry, I was able to develop a lesson for my students that used programable drones." Engineering and Physics Teacher*

Development of Technical Courses and Modules at the High School

As a result of their participation in professional development activities and their engagement with industry, teachers developed new technical courses and added technical units to their existing courses. In 2019, three courses Introduction to Engineering, Introduction to Soldering and Principles of Technology, were added to the high school curriculum. From 2020-2022 the following five technical courses were added to the curriculum: Applied STEM, Drones, Introduction to Coding I, Introduction to Coding II, and Robotics. In addition, the following STEM courses with an applied science focus were added to the curriculum: Chemistry in the Community, Biotechnology, Marine Science, Meteorology, Oceanography.

As of fall 2023, the high school had 23 technical courses on their schedule.

Technical Modules were also added to a number of existing STEM courses. The Plant Science and Engineering courses added a joint unit on hydroponics, the Construction Technology added units on building sheds and building clay ovens, the Biology course added a unit on microorganisms, and the Biotechnology course incorporated a unit on earning industry recognized laboratory skills badges and credentials.

Impact on Students

Over the course of the project, 859 high school students participated in the Experience STEM College program. Although the companies introduced during Experience STEM are local firms, when surveyed only 16% of the students had heard of the companies before participating in the program. The program made students more aware of the technical careers and technical employers in their community. When surveyed on the actions that they would take after the event, 95% said that they planned to talk with their guidance counselors and teachers about STEM Careers and Degrees. They also stated that the program increased their awareness of the STEM programs offered at the community college.

The technical courses offered at the high school attracted many students and additional sections of Engineering, Robotics and Biotechnology were added to the schedule.

The community college dual enrollment STEM courses offered at the high school are AP Biology, AP Chemistry, AP Environmental Science, and Soldering. In addition, high school juniors and seniors can take courses for free at the community college through the High School Partnership Program. Students enrolled in either of these programs are counted as participating in dual enrollment.

Prior to the start of this project in 2018 only seven THS students earned college credit through the dual enrollment programs at the community college. This number rose to 100 after the first year of the project and while the numbers dropped during the pandemic, they still remained significantly higher than at the start of the program.

Table 2. Number of Students Participating in Dual Enrollment Data

Academic Year	#of THS Students Enrolled in Community College Credit Classes
2018-2019	7
2019-2020	100
2020-2021	45
2021-2022	85
2022-2023	72

Table 3. Demographics of Students Participating in Dual Enrollment

Demographic	%THS Students 2022	%THS Students 2023
Asian	7%	13.6%
Black	-	6%
Hispanic	33%	34.8%
Multirace	-	4.5%
White	60%	41.1%

The number of high school students determined to be college ready increased. College readiness is determined by earning 3 or more college level credits or by earning a 3 or higher on AP or ACT tests. In 2018 none of the ELS students and only 9.4% of the Hispanic students were classified as "College Ready"[5] and in 2022 17.1% of the ESL students and 26.1% of the Hispanic students were listed as "College Ready".[8]

The number of students overall enrolling in the community college STEM programs also increased. In the fall of 2018, there were 113 students enrolled in the college STEM programs. In the fall of 2022, we had 151 students enrolled in our STEM programs.

Discussion

Between 2018 and 2022, Torrington High School added thirteen technical classes to the curriculum and enhanced three existing classes with technical based units. These courses proved to be of interest to the students and additional sections of engineering, robotics, and biotechnology were added to meet student

demand. The number of Torrington students who participated in the dual enrollment classes also rose from seven in 2018 to 72 in 2022 with a pandemic peak of 100 in 2019-2020.

In addition to seeing an overall increase in registration in dual enrollment courses, we also saw an increase in the number of underserved and minoritized students participating in the dual enrollment program. In 2021, 33% of the students registered in dual enrollment courses identified as Hispanic and 7% identified as Asian. In 2023, 13.6% of the students identified as Asian, 34.8% as Hispanic, 4.5% as multiracial, and 6% identified as Black.

Enrollment in dual enrollment courses has been shown to increase student interest in STEM careers and enrollment in college STEM programs.[3,7] We found that there was a 33.6% increase in enrollment in STEM programs at Northwestern Connecticut Community College from 2018 to 2022. While there are a number of factors that play a role in enrollment in college STEM programs, the increase in enrollment in STEM programs at the college is positively correlated with the increase in dual enrollment.

Limitations

There are many factors that influence a student's decision to participate in a dual enrollment course, these include both internal and external factors. Studies have shown that *"students' decision making is a product of their habitus—defined as internalized dispositions, beliefs, and perceptions deriving from past experiences and shaped by their environment."*[9] Many of these factors are out of the control of the school or college and were not evaluated in this study. However, by increasing the number of technical courses offered at the college, we were able to change the academic environment, and this played a role in the increase in the number of Torrington High School students who took dual community college enrollment classes.

This project did not separately measure the impact of technical courses and technical modules. Both were produced by the teachers participating in the project and students were exposed to both. It might be beneficial to look separately at the impact of courses vs modules but this study did not collect that data.

Conclusion

Proving technical career focused professional development opportunities for high school teachers led to an increase in the number of technical courses they offered at the school. When the high school increased the number of technical courses and included career-based modules in their STEM classes, student participation in dual enrollment courses and in enrolling in STEM programs at the college

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