



East Tennessee Noyce STEM Teacher Preparation Program

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BEVERLY SMITH

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Abstract

There is a critical shortage of STEM teachers in high-need fields, especially in Computer Science, Engineering/Engineering Technology, in the southern Appalachian region. This paper describes an NSF funded Noyce Track 1 Teacher Recruiting program at East Tennessee State University (ETSU) awarded in 2019. The program is administered in partnership with local high-need school districts in the First Congressional District of Tennessee as well as four nearby nonprofit educational organizations, namely the Gray Fossil Site/ETSU Natural History Museum, the Hands- On Museum, the Pisgah Astronomical Research Institute, and the Bays Mountain Planetarium, and three summer science camps: the ETSU Governor's School, the ETSU Renaissance Camp, and the ETSU Computing/Technology Camp. The program has three parts: 1) a summer teaching internship program for undergraduate STEM majors designed to recruit students into the teaching profession, 2) scholarships and mentoring for a Masters of Arts in Teaching (MAT) program, and 3) a mentoring program and continuing professional development for newly minted teachers to retain them as teachers. It is focused on Physics, Chemistry, Engineering/Engineering Technology, Computer Science, and Mathematics. The heart of the program is a 4+1 bachelors/post-baccalaureate program in which students obtaining undergraduate degrees in high-need STEM fields are recruited for the MAT program. Thus far two cohorts of seven students completed the internship programs and all showed interest to become STEM teacher in their respective fields. Of them one student completed the MAT program and currently teaching in high-need school. We anticipate that ETSU Noyce program will create a group of teachers who will be able to inspire future generations of STEM professionals in Northeast Tennessee region.

Introduction

East Tennessee State University (ETSU) is a research- intensive regional university of 13,546 students serving the Southern Appalachian regions of East Tennessee, Eastern Kentucky, Western North Carolina, and Southwest Virginia (ETSU Factbook, 2021). The university was initially founded as a teacher's college but has grown to include nine colleges, including a medical school, a pharmacy college, and a public health college. This Noyce program involves a collaboration between three colleges at ETSU: Arts and Sciences, Education, and Business and Technology. These three colleges dominate the undergraduate enrollment at

ETSU, amounting to 36%, 16%, and 26% of the total respectively. Over the last five years, 37% percent of entering freshmen at ETSU are first-generation college students, and 18% percent are non-traditional. Many students hold full-time jobs or rely extensively on student loans. Many have family responsibilities in addition to being a college student. The fraction of ETSU students receiving Pell grants is 41%, while the average student debt for graduating students in 2019 is \$27,866 (THEC, 2021).

In part because of this issue, in recent years the university has been emphasizing an alternative path into the teaching profession for STEM students: completion of the undergraduate degree in their STEM field first, followed by a year of post-baccalaureate study focused on teacher training and licensure. This program also awards the student a Master's in Teaching degree. With ETSU's 'Accelerated Bachelors-to- Masters' program, students can take some of their MAT courses during their senior year. There are several advantages to this alternative 4+1 path. First, with the Master's degree, the starting salaries in local school districts are \$3200 - \$3900 higher than with just the Bachelor's degree. This higher salary helps to retain teachers in the profession in an area where salaries are lower than the national average. Second, many STEM majors decide in their sophomore, junior, or senior years to pursue teaching, at which point it is difficult to complete all the courses needed for the education minor without extending the undergraduate years. The 4+1 option gives them the opportunity to complete the teacher training in just one additional year, with the bonus of a Master's degree. A third reason for following a 4+1 route is that students can fully focus on their STEM courses first. Then, once they are confident in their knowledge of their STEM content material, they can focus on the teacher training. Older and more mature students with the STEM degree in hand can make a firmer decision about whether to pursue teacher certification. This means they are less likely to drop out of the program and more likely to stay in the teaching profession.

The main difficulty with the 4+1 track is the lack of financial support for that final year. The largest roadblock for enrollment in STEM teacher education seems to be the financial strain of post-baccalaureate education (Stewart & Stewart, 2010). In our experience, many of the students that start the MAT program either drop out or take two or more years to finish the program. The reason for this is generally financial; most of our students need to work in addition to taking classes and cannot handle the workload. The

MAT program is intensive, with both daytime and evening obligations, so it is a full-time commitment. This is one of the primary motivations for our Noyce project – to provide scholarships so that teacher candidates in the MAT program can be full-time students and concentrate on their studies, without the need for an outside job. A second motivation for the project is to encourage undergraduate STEM majors to consider the MAT program by providing pre-teaching experiences in the form of paid summer teaching internships. A recent APS study found that the most common reason undergraduate Physics majors cite for not going into teaching as a profession is the fear of not being able to handle classes of “uncontrollable or uninterested students” (Marder, Brown, & Plisch, 2017). Our goal is to diminish this fear by providing students with pre-teaching experiences with extensive mentoring to increase their confidence in their ability to handle a classroom and be an effective teacher. The same APS survey asked recent Physics graduates about the features of their job that affected job satisfaction. The Physics graduates who had become teachers were nearly six times more likely to say their job made a difference in people's lives, which contributed to their job satisfaction. Another goal of the proposed pre-teaching experiences is to help students discover the rewards of teaching.

The Need for Highly Qualified Teachers

All of the school districts in the eastern tip of Tennessee qualify as high-need districts. Figure 1 shows Eastern Tennessee, with the counties marked. The counties are color-coded according to the percentage of students that are “economically disadvantaged,” based on the Tennessee Department of Education 2020-21 Report Card. All 17 school districts east of Anderson County (150 miles from the easternmost point of Tennessee) have economically disadvantaged percentages greater than 25%, thus are considered high-need districts. ETSU is located in Washington County and places teachers as far away as Knox County.

The United States has a severe, long-term shortage of highly qualified STEM teachers, that is, teachers who have not completed a degree in their discipline (Table 1; from Marder, Brown, and Plisch 2017). Teachers who lack deep knowledge in their subject areas may not be able to fully inspire future generations of scientists and engineers. To quantify the need for STEM teachers locally, we surveyed the principals of 28 high schools in 9 local

counties in Tennessee. We asked which areas are the hardest to staff with qualified teachers. Twelve high school principals answered the survey (Figure 2). Physics was the area that was the hardest subject for which to find highly qualified teachers, with nine of the 12 principals (75%) ranking it hardest. Math was ranked hardest by 3/12 (25%) and second hardest by 4/12 (33%).

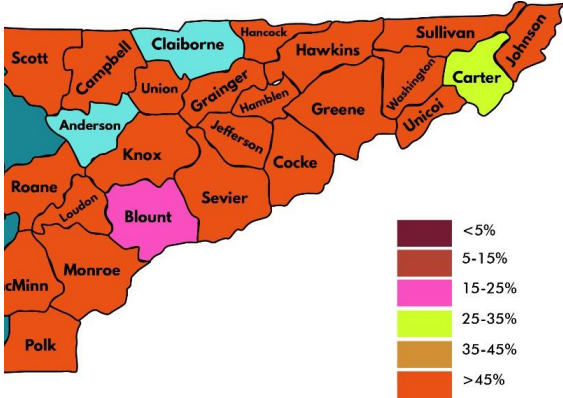


Figure 1: Percentage of Economically Disadvantaged Students Per County In Eastern Tennessee (From The Tennessee State 2020/21 Report Card)

Table 1: Teachers without a Major or Minor in the Subject: Nationwide Statistics (Marder, Brown, and Plisch, 2017)

Physics	Chemistry	Physical Science	Biology	Math
63%	66%	62%	35%	38%

Chemistry was not ranked hardest by all Principals; however, it was ranked second hardest by 6/12 (50%). Computing is the lowest priority, being ranked second hardest by 1/12 (8%). We also asked the principals in which subjects they are likely to need new teachers in the next five years (Figure 3). Principals who responded to this poll anticipate that the areas of highest need in the next five years will be math (74%), physics (41%), chemistry (8%), and computing (8%). Although our survey of high school principals did not include Engineering/Engineering Technology, we anticipate an increasing need in that field as well. Overall, in the U.S., the numbers of qualified Engineering and Engineering Technology teachers being produced is

decreasing. Using data from the Technology & Engineering Teacher Education Directories (Rogers, 2015), (Moye, 2017) found that the supply of teachers in this field has dropped by a factor of three between 2000 and 2016. At the same time, the demand for such teachers is increasing. Teachers with bachelor’s degrees in Engineering/Engineering Technology are needed to teach courses in Engineering, Construction and Robotics in local schools. Although ETSU has reasonably high numbers of bachelor’s degree recipients in the targeted STEM

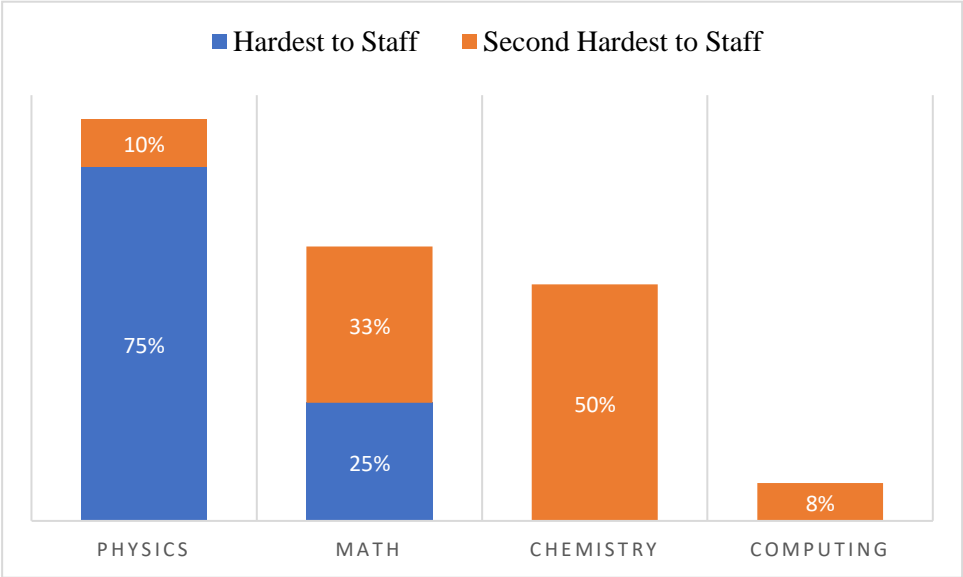


Figure 2: Hardest Subjects to Staff

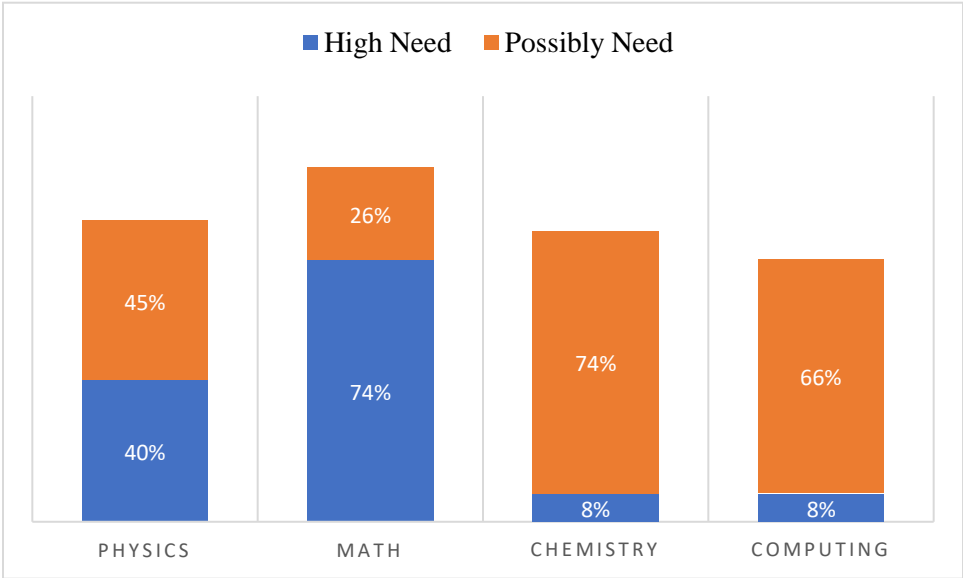


Figure 3: Subjects Needs New Teachers in Next 1 to 5 years

fields, only a small fraction of them also minor in Education and the MAT program has only graduated a handful of STEM majors. The present production rate does not meet the need of the local schools. The objectives of our NSF funded project are: *Goal 1: Recruit high performing STEM undergraduates into the fifth-year MAT program and summer teaching internships at local STEM outreach venues. Goal 2: Prepare highly effective STEM teacher candidates to teach in high need school districts. Goal 3: Place highly qualified STEM teachers in high needs school districts and retain them beyond the period of mandatory service to repay scholarships.* This paper is mainly focused on the summer teaching internship and its efficacy to motivate students to pursue teaching career.

Summer Teaching Internships

To recruit high-performing STEM undergraduates into the MAT program, we have started a summer internship program in which students are employed as Teaching Interns at local and regional science museums, science institutes, and local STEM camps. The interns receive training to lead group exercises, run classroom activities, and lead group tours. These experiences help the students gain confidence in their abilities to teach, which we believe will encourage them to consider teaching as a career. Research shows that early teaching experiences are a key factor in recruiting STEM students into the teaching profession (Otero, Pollock, McCray, & Finkelstein, 2006; Task Force on Teacher Education in Physics, 2012). Students who have had prior experience working with school-aged students are more motivated to become teachers (Coon, 2020; Westerlund, Radcliffe, Smith, Lemke, & West, 2011; Eick, 2002; Tomanek & Cummings, 2000). Our partner organizations include local and regional science museums and science institutes and outreach programs at ETSU.

Our plan is to hire eight Summer Teaching Interns each summer, for an average of 5 weeks each and place them to one of the partner organizations. Before starting their Teaching Internships, our participating students meet together as a group with the Noyce PIs and our returning post-MAT in-service teachers, as well as representatives from our partner organizations. The expectations and responsibilities of the internship jobs is outlined at this Orientation Meeting. Each Intern is assigned three mentors for the summer, one from the partner organization they will be working with, one from our group of post-MAT in-service teachers, and a faculty member from their major Department (one of the

Noyce co-PIs). Immediately after the Orientation Meeting, the interns meet individually with their assigned team of mentors. Following the initial Orientation Meeting, the interns participate in a Teaching Workshop run by Noyce team and the in-service teachers. At this workshop, the interns learn some classroom management techniques and methods for building connections to students. They are also given an overview of what to expect from students at different grade levels. Research shows that attending workshops on teaching helps increase interest in teaching careers (Klemballa, 2005).

Throughout the summer, the interns, the mentors, and the Noyce team meet weekly for lunch. At these meetings, the interns provide updates on their activities. Other STEM faculty, including Department Chairs and faculty advisors, are invited to one of these lunches to meet with the interns and learn about the Noyce program. The professional advisors for the STEM majors are also invited to a lunch to familiarize them with the program. We also invite the Officers of department student clubs (e.g., the Society of Physics Students) to one of the lunches. Building relationships between the interns, and faculty and student leaders in their departments help to maintain their connection to their discipline. At these lunches, careers in teaching are discussed as well as other possible career paths. Noyce team and interns speak during one of the lunches about the MAT program and the Noyce post-bac scholarship program and the interns are encouraged to consider applying for the MAT program. The Deans of the three colleges involved (Education, Arts and Sciences, and Business and Technology) are also invited to speak at one of the summer lunches. The inclusion of Department Chairs, Deans, and other faculty in these lunches help advertise the Noyce program on campus and highlight the importance of teacher training to STEM faculty and the administration.

During their internships, the interns make regular entries in journals describing their experiences. We use the D2L (Desire-to-Learn) course software for these journals, which are made available to all the mentors and the other interns. In D2L, we have set up a discussion board for interns and mentors, on which questions and comments can be posted. The interns are expected to post regular reflections on their internship activities to this discussion board. They are asked to give their perceptions on the activities and learning of their students, to comment on both positive and negative interactions they had with the students, and to discuss their own growth as teachers. The mentors and their peer interns then have the opportunity to respond to these postings with suggestions, encouragement, and feedback. Issues such as

classroom management and student engagement and learning were discussed. Several times during the summer, the mentors observe the interns leading group exercises or other classroom activities. In some cases, the student presentations are videotaped for later playback.

Afterwards, the mentors meet privately with the intern to provide feedback and advice on their presentation. Research shows that frequent interactions with experienced teachers helps encourage undergraduates to consider teaching as a career (Coon, 2020). Afterwards, we require each participant to give a presentation in their home department on their internship experiences. This is done as part of the regular department seminar series, to get the widest possible audience. This helps advertise the program to other students and will emphasize the importance of careers in teaching and public outreach to other students and to faculty.

Results

ETSU Noyce program is currently in its third year. We resumed Noyce activities in spring of 2021 after suspending all activities in 2020 due to COVID pandemic. Data presented in this paper are based on the first two years of activities. At both the beginning and the end of the summer, we ask the interns to take the questionnaire about attitudes concerning teaching produced by the APS (Marder, Brown, & Plisch, 2017). We look for a difference in the responses before vs. after the internship. As noted above, a major barrier to recruiting STEM students into the teaching profession are their worries about classroom control. We hypothesized that an intensive pre-teaching experience, such as our Teaching Internships, can diminish these fears and students will become more open to becoming teachers. We also expect that many of the interns will find teaching personally satisfying and rewarding. The D2L discussion board postings and the APS survey responses are used to test these hypotheses. In particular, we look at the intern's responses to the APS survey items "inspire students while still impressionable", "likes teaching/mentoring/inspiring", and "make a difference/have an impact".

Seven students completed the summer internships: 4 in summer of 2019 and 4 in summer of 2021. Out of the eight students, two had Mathematics major, one Engineering major, one Engineering technology major, two Physics major and 1 Chemistry major. In terms of academic status, there were 2 sophomores, 3 juniors and 2 seniors who completed the program. Students were placed in participating organizations' summer camps: four in Hands

On Discovery Center in Gray, two in ETSU Renaissance Camp and one in Langston Centre. Typical activities that students performed were leading classroom activities, preparing and giving presentations on topics in their area of expertise, and giving scientific demonstrations. In the pre-survey half of the students mentioned that they have had experience working in an informal teaching setting with children (tutoring, pre-school, youth groups, etc.). The post survey shows that students' satisfaction with the internship was extremely high. The students mentioned that "satisfaction of teaching", "inspiring students", "checking with students to see how they're doing", "aiding them with challenges in teamwork" were all appealing them to be a teacher. One student mentioned "The most appealing thing about teaching middle or high school is the relationships I can form with the students. I have really enjoyed working with and being around the students of the summer camp and I know that forming the same connections as a high school teacher would be incredibly fulfilling. Also, the internship has further demonstrated to me how much I love talking about science and particularly the scientific fields which interest me, Physics and Astronomy." The most important finding of the survey was how the internship inspired them to be a middle or high school teacher. Figure 4 shows that students' interest to be a middle or high school teacher increases five-fold after completing the internship.

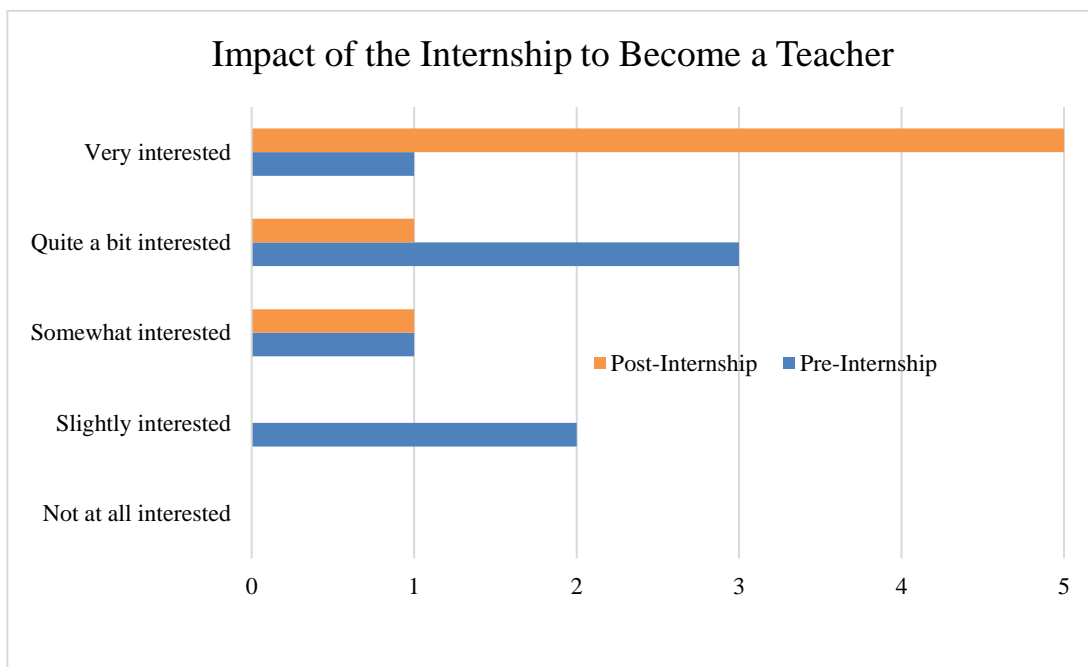


Figure 4: Effect of the Summer Teaching Internships

By the end of summer 2021, one intern joined the MAT program, completed the program in one year and currently is working in a high need school. One intern decided to pursue PhD in his major with the goal of becoming a college professor. The remaining five interns are currently in different years in their majors and yet to make a decision to pursue MAT program. Even for students who do not go on to careers as teachers, we anticipate that participation in teaching internships will have positive consequences. In a study of STEM majors at the University of California, (Whang-Sayson, Daniel, & Russell, 2017) found that those who participated in a pre-teaching experience program but did not go into teaching as a career had greater interest in educational outreach in the workplace, were more likely to volunteer in public schools, and had more appreciation and respect for public school teachers. There are two students who did not participate in the summer internship, but applied for the MAT program (funded by this grant) after completing their undergraduate majors. Both completed their MAT programs and currently working as Middle School teacher.

Conclusion

There is a shortage of highly qualified STEM teacher in the southern Appalachian region served by ETSU. ETSU is not producing STEM teachers at a high enough rate to meet the need, in spite of reasonably high numbers of students graduating with bachelor's degrees in these fields. To place STEM majors into the teaching profession, undergraduate STEM majors were recruited and placed as Teaching Interns at a variety of local science learning centers over the summer of 2019 and 2021. Each intern received mentorship from the host center, from their home Department and from an in-service teacher in their field. At the beginning of the summer, the Interns also attended a Teaching Workshop at which they learned the basics of classroom management, techniques for connecting to students, and what to expect from students at different age levels. Data gathered part of the project shows interns were highly satisfied with the summer program and their interest to be middle/high school teacher increased significantly as a result of completing the internship. We strongly believe that the grant activities will build a network of interested students, STEM educators, administrators and supporters to maintain the rate of production of new STEM teachers and alleviate the need of STEM teaching in this region.

Acknowledgement and Disclaimer

This material is based upon work supported by the National Science Foundation under Grant No. 1851631. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

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