

Chapter 3

Teach (STEM)³: A Clinical Residency Model for Preparing Effective STEM Teachers

Katherine W. Stickney,^{*,1} Kimberly M. Baker,² and Deborah D. Sachs³

¹Chemistry Department, University of Indianapolis, 1400 East Hanna Avenue, Indianapolis, Indiana 46227, United States

²Biology Department, University of Indianapolis, 1400 East Hanna Avenue, Indianapolis, Indiana 46227, United States

³School of Education, University of Indianapolis, 1400 East Hanna Avenue, Indianapolis, Indiana 46227, United States

*E-mail: kstickney@uindy.edu

The University of Indianapolis Teach (STEM)³ (UIndy TS3) program is a clinical residency teacher preparation program in which candidates earn a Master of Arts in Teaching degree with licensure in Chemistry, Biology, or Math. UIndy TS3 consists of multiple layers of support, including a clinical residency with clinical mentor teachers and clinical faculty who also serve as university supervisors, integrated and scaffolded university coursework, which includes clinical seminars and classroom observations, and two years of in-service mentoring. Evaluation and retention results indicate that candidates are well-supported in their high-need classrooms by these program components, and our 3-year retention rate of 93% over eight cohorts is higher than the national average. Moreover, the clinical mentor teacher (CMT) is enriched by the candidate's presence in the classroom, as the candidate imports new teaching methodologies (such as project-based learning) and technologies to the classroom that in turn inform the practice of the CMT. School administrators are also positively impacted by interacting with the candidates, both by keeping apprised of the challenges that new teachers face and by learning new ways to engage students. The efficacy of UIndy TS3 is proven by our 100% placement rate, long-term retention of program graduates, and their recognition as teacher leaders.

The Critical Teacher Shortage

The United States is continuing to face a critical shortage of qualified teachers in STEM (science, technology, engineering, and mathematics) disciplines. According to the 2017 report by the U.S. Department of Education (*1*), 48 states reported teacher shortages in math and 43 states reported

shortages in science. Schools experiencing teacher shortages have lower levels of student achievement (2) which limits student access to STEM careers. Furthermore, teacher shortages disproportionately affect students in high-poverty and high-minority schools (3). Given the growing projected demand for STEM professionals in the workforce (4), it is imperative that teacher education programs prepare highly effective STEM teachers who possess both content and pedagogical knowledge for teaching in high-need schools.

One of the key factors contributing to teacher shortages is attrition (2). However, teachers who receive more pedagogical training during their pre-service programs, along with post-graduation mentoring support, are more likely to stay in teaching (5, 6). The University of Indianapolis Teach (STEM)³ (UIndy TS3) program was created to prepare highly effective STEM teachers who have the skills and foundational training to be successful in the teaching profession. Our goals are to graduate candidates who possess both content and pedagogical knowledge and to provide personalized mentoring support during their early career to reduce attrition. Therefore, the TS3 program integrates the best practices of: a year-long clinical residency; pedagogical training in effective teaching strategies including project-based learning (PBL); and two years of post-residency mentoring support.

The UIndy Teach (STEM)³ Master of Arts in Teaching Program Framework

The details and framework of our program, including a description of the partnerships, initial program development, the TS3 application and admissions processes, program objectives, pre-service components (residency, support, and coursework), post-graduation mentoring, and program leadership are described below.

Collaborating Partners and Program Planning and Development

UIndy TS3 is a collaborative program between the UIndy Shaheen College of Arts and Sciences (SCAS) and the School of Education (SOE) with the curriculum originally developed by SCAS and SOE faculty, along with district partner administrators and faculty (7). The curriculum was successfully used for eight years with the UIndy Woodrow Wilson Indiana Teaching Fellowship (WWITF) program whose graduates had a 100% placement rate. The WWITF curriculum was revised through a reflective and iterative process and provided the foundation of the coursework for UIndy TS3.

UIndy SCAS and SOE faculty have established a strong partnership, driven by the support of the deans' and provost's offices, that links the content expertise of SCAS faculty with the pedagogical expertise of SOE faculty. Our STEM education initiatives have been developed through a long history of SCAS and SOE conversation, collaboration on joint committee work, collaboration on SOE curriculum revisions, submission of a successful NSF Noyce capacity building grant proposal and NSF Robert Noyce Teacher scholarship grant proposal, and ongoing work in developing, sustaining and transitioning the WWITF program to the UIndy TS3 program. The SOE dean led the effort of identifying and connecting with district administrators. The relationships with partnering districts were then solidified with a memorandum of understanding. As a result, UIndy SCAS and SOE faculty fully collaborated on program and curriculum development with administrators and faculty from partnering districts (7). Our new curriculum implemented several innovative practices, including co-teaching PBL content courses (SOE and SCAS faculty) and co-teaching clinical methods courses (SOE and partnering district faculty). This co-teaching model successfully

integrates best practices in pedagogy with STEM content (8). Our prior experience in establishing partnerships, creating a program framework, and developing a program infrastructure, along with receipt of an NSF Robert Noyce Teacher Scholarship Program grant (NSF DUE #1660653), allows us to effectively deliver and sustain the UIndy TS3 program.

Teach (STEM)³ Application and Selection Process

Candidates applying to UIndy TS3 are expected to have graduated from an accredited college or university with a minimum GPA of 3.00 on a 4.00 scale and a bachelor's degree or higher within a specific discipline in science, technology, engineering or mathematics or be working in or had a career in such field or a related area, including retirees from STEM professions. The candidate must be a U.S. citizen or national, or a permanent resident alien. As part of their application, each candidate completes a graduate admission application to UIndy, provides two letters of recommendation, and participates in a face-to-face or online interview during the application process. Candidates must also have qualifying scores on state licensure exams prior to their acceptance into the program.

An admissions committee composed of Shaheen College of Arts and Sciences faculty and School of Education faculty reviews each candidate's application materials. Our application criteria allows selection of the highest quality candidates and recruitment of members of historically underrepresented groups, including minorities and women. Offers of admission to UIndy TS3 are based on recommendations of the admissions committee.

UIndy Teach (STEM)³ Objectives

UIndy TS3 tightly packages effective initial teacher preparation into a 1-year Master of Arts in Teaching with a strong emphasis on best-practices. Graduates of UIndy TS3 serve high-need schools and districts as teacher leaders who are able to:

- Demonstrate content mastery.
- Translate content knowledge into culturally and developmentally responsive curricula.
- Employ a variety of strategies to encourage students' literacy, engagement, self-efficacy, and problem-solving, performance, and critical thinking skills.
- Employ differentiated instruction to meet the needs of all students, including students with exceptionalities.
- Facilitate effective individual and group interactions.
- Assess the impact of professional practice on student achievement.
- Use data-driven reflection to modify professional practice.
- Advocate for high-quality urban education.

Why Teach (STEM)³?

The name "Teach (STEM)³" is based on the overarching "who, what and where" components that comprise the program and the three elements that are interwoven into each of these components. The program elements funnel into a comprehensive and integrated experience for the candidates, as illustrated in Figure 1. The UIndy TS3 program consists of faculty, mentors, and candidates all working together to help candidates successfully complete the residency, coursework and mentoring requirements of the program. This collaboration occurs in the three venues integrated into the program infrastructure: the partnering school districts, the university, and the employers.

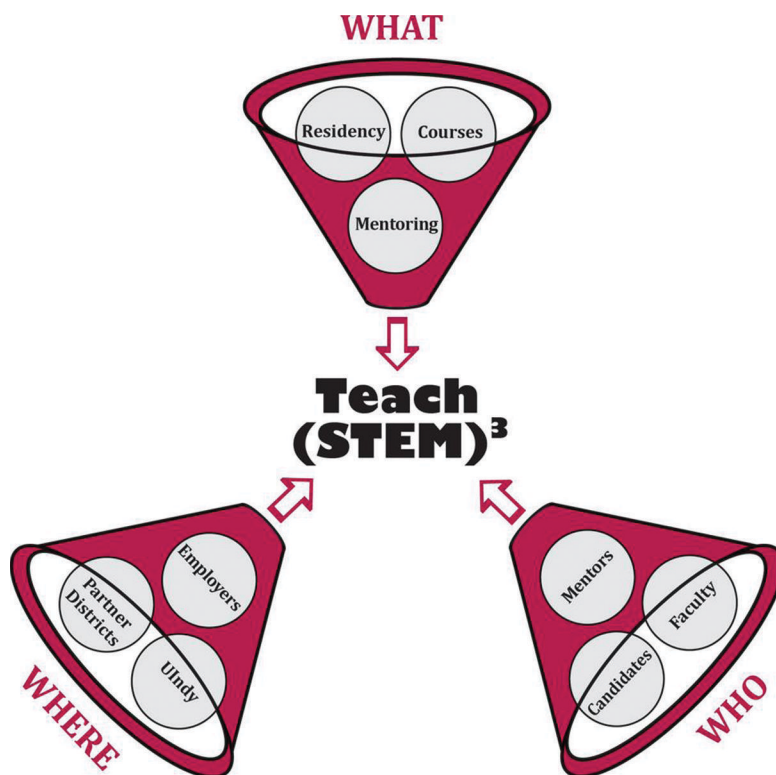


Figure 1. The UIndy Teach (STEM)³ program model.

Urban Clinical Residency

To prepare effective teachers for the 21st century, especially in high-need schools, the National Council for Accreditation of Teacher Education Blue Ribbon Panel on Clinical Preparation and Partnerships for Improved Student Learning (9) and the American Association of Colleges for Teacher Education (AACTE) (10) advocate that teacher education programs center on clinical practice.

The urban teacher residency (UTR) model, initially developed in Boston and Chicago, integrates coursework with classroom practice in a year-long residency in which teacher candidates work under the guidance of a mentor teacher in partnering high-need school districts. After being hired as teacher of record, candidates continue to receive support for an additional two years (11, 12). Following the guiding principles of effective UTR models, candidates in UIndy TS3 are strategically placed in a school from the first day of teacher meetings until nearly the end of the academic school year. UIndy has longstanding and productive relationships with three urban districts that have provided valuable clinical residency sites for the TS3 program. Other schools serve as additional field experience sites. These district partners have clearly expressed their enthusiasm for the opportunity to grow their own future colleagues and to play a prominent role in the teacher education process. In fact, our partnering districts have hired 41 out of 87 (47%) of our program graduates. An assistant superintendent from a partnering district called our program a “tremendous model [with] great university support.” He also stated that the quality of the teachers in their first year of employment was “way above average,” echoing the comments of other school administrators that TS3 graduates are better prepared than typical first year teachers.

District administrators identify excellent science and math teachers to serve as program leaders within their school district for UIndy TS3. These clinical faculty (CF) teacher leaders serve as the school-based liaison between the university and the district. CFs also assist candidates in navigating the schools where they are placed. In addition, they serve as university supervisors who complete observations of the candidates, conference with candidates about their teaching, and complete evaluations of each candidate. CFs identify cooperating mentor teachers (CMTs) to host the candidates in their year-long clinical residency.

CMTs are chosen based on demonstrated teaching excellence in their content area and their ability to effectively mentor a candidate. During the fall semester, each CMT invites the TS3 candidate to teacher planning days and meetings prior to the start of the school year, and department meetings, professional development opportunities, and special events during the school year whenever possible. The CMT also orients the candidate to the school, provides copies of textbooks and curriculum guides, communicates school policies and emergency procedures, introduces the candidate to technology and resource personnel, and shares the classroom management plan and established routine. Additionally, the CMT prepares students for the candidate's participation, hosts the candidate in at least one class – called the candidate's focus class – every Monday, Tuesday and Wednesday, supports the candidate in designing and teaching several lessons, involves the candidate in co-teaching throughout the semester, completes a midterm and final evaluation of the candidate, and remains in regular contact with the CF regarding the candidate's progress in the program. During the winter/spring semester the CMT allows the candidate to teach the focus class full-time in January and February, then allows the candidate to progress to teaching a full load of classes in March, April and May. With support, the candidate has the responsibility for the classroom, including following individualized education plans (IEPs), designing student assessments, keeping records, completing forms, and communicating with families. The CMT observes lessons and provides feedback to the candidate, completes formal observations of the candidate throughout the semester, completes a midterm and final evaluation of the candidate, conferences regularly with the candidate to provide instructional support and feedback, and remains in regular contact with the CF regarding the candidate's progress in the program. CFs and CMTs attend training sessions prior to the start of each semester and participate in debriefing and program evaluation sessions at the end of the school year.

The TS3 Program Structure: Rationale and Overview

Weaving education theory and classroom practice together in a year-long residency is one of the defining principles of excellent teacher residency programs (11). Pre-service teachers who complete multicultural education courses in conjunction with clinical practice have a much stronger understanding of instructional practices that can be utilized to help culturally diverse students than pre-service teachers who complete coursework only (13). Furthermore, teacher education programs that foster multicultural awareness and provide teachers with strategies to meet the diverse needs of their students can lead to higher teaching efficacy. This in turn may increase teacher retention in high-need schools (14). For these reasons, the TS3 program starts with an intensive summer training focused on diverse learners (see coursework below) and a self-assessment of content standards and core concepts in the disciplines. Candidates then begin the clinical urban residency component of UIndy TS3 by attending clinical residency orientations in each of the partnering districts. The orientations are designed to familiarize candidates with each district's administration, programs, and initiatives, as well as with the district's demographics, resources and geographic boundaries. Candidates begin their work in the schools by attending the first day of teacher meetings with their CMT. From there, they segue into the classroom and begin assisting with various teaching activities

and ultimately progress to teaching a full schedule of complete lessons under the guidance of their CMT. In the first semester of our clinical residency program, candidates are immersed in partner school classrooms three days per week and are on the UIndy campus two days per week for coursework. In the second semester, candidates are in partner school classrooms five days a week, with coursework occurring two evenings per week.

While participating in the urban clinical residency component of UIndy TS3, candidates simultaneously take 38 graduate credit hours of coursework toward earning a Master of Arts in Teaching (MAT) degree. A full description of the curriculum is below.

Coursework

After completing the orientation to UIndy TS3, candidates take two summer courses in order to frontload important concepts and content prior to their work with students.

Project in Equity and Diversity: (In)Equity and Diversity in Indianapolis Schools and Communities: Candidates employ a variety of interdisciplinary research strategies to learn about multicultural education, special education, and the role of families and communities in urban schools, with a particular emphasis placed on partnering districts.

Project in Curriculum and Instruction: Learning Theories and Urban Classroom Practice: Candidates use literacy-based theory to develop instructional and assessment approaches for students. Particular emphasis is placed in developing an inquiry approach, critical literacy, literacy-based strategies for teaching science and mathematics, the role of academic language in teaching and learning, and the needs of English language learners.

First semester coursework consists of the following courses which are integrated with classroom experiences:

Project in Adolescent Psychology and Development: Adolescent Identity, Culture, and Learning: Candidates consider adolescent development from multiple and intersecting perspectives, including approaches to learning and the relevance of psychological and cultural points of view. Particular emphasis is placed on the application of research in adolescent development to instructional planning, relationship building, and classroom management.

Middle/High School Science and Math Methods: Candidates examine methods for teaching science or math with a focus on urban classrooms. This course emphasizes strategies for designing and teaching standards-based lessons, including strategies for differentiating instruction, incorporating instructional technology, assessing student learning, promoting student engagement and using data to modify professional practice. Separate sections of this course, taught by clinical faculty members from partnering schools, are offered for math and science candidates.

Project in Science and Math Pedagogy: Candidates learn strategies for incorporating experiential learning into inquiry-based science and math classrooms. For science candidates, particular emphasis is placed on designing, preparing and delivering safe laboratory and field experiences. For math candidates, particular emphasis is placed on real-

world math applications. All candidates are introduced to the theory and practice of project-based learning (PBL). (Note that this course is team taught by content-specific College of Arts and Science professors and a PBL-expert School of Education professor and culminates with a PBL showcase that includes our community partners.)

Clinical Practice Seminar: As an accompaniment to the Clinical Practice Residency, this seminar includes instruction in various aspects of teaching, including planning, instruction, assessment, and classroom management. An emphasis is placed on developing a positive classroom culture and designing effective lessons.

Clinical Practice Residency: This residency experience directly connects with the instruction provided in the Clinical Practice Seminar. Candidates are placed in a “focus class” with one primary mentor, but have experiences in a variety of school settings. Experiences are scaffolded to increase the candidates’ teaching responsibilities: guided observations, co-teaching and tutoring, working with small groups of students, and teaching classes.

Second semester coursework consists of the following courses which are integrated with school and classroom experiences:

Project in Science and Math Pedagogy II: Candidates continue to explore strategies for incorporating experiential learning into inquiry-based science and math classrooms, with a particular focus on planning and facilitating student learning in a project-based environment.

Project in Urban Education: Urban Schools and Schooling: Candidates investigate school improvement initiatives taking place in partnering districts. Particular attention is paid to what definitions of “school improvement” are valued and by whom, as well as to teacher action research and teacher leadership.

Professional Residency Seminar I: As an accompaniment to the Professional Residency, this seminar includes instruction in various aspects of teaching with a particular emphasis on developing and implementing effective lessons, assessments, and classroom management strategies/plans.

Professional Residency Seminar II: As an accompaniment to the Professional Residency, this seminar includes instruction in various aspects of teaching with a particular emphasis on developing and implementing effective lessons, grading and assessment practices, classroom management strategies/plans, legal and ethical considerations in education, and teacher leadership.

Professional Residency: This residency experience directly connects with the instruction provided in the Professional Residency Seminars I and II. Candidates have experiences in high-need urban schools outside the partnering districts, and are mentored as they begin teaching one focus class full-time in a partnering district. Candidates take over a full-time teaching schedule under the supervision of a cooperating mentor teacher and a university supervisor.

Exit from Program Portfolio: Candidates complete a series of training modules designed to guide them through compiling each task of the edTPA. Candidates also receive training on overarching concepts in the edTPA, such as understanding Academic Language and infusing Academic Language into their teaching. Lastly, candidates develop and submit their edTPA Exit from Program Portfolio.

The final coursework for UIndy TS3 takes place in the summer immediately following the urban clinical residency component and consists of a Capstone Seminar during which candidates complete a program outcomes project, revise a classroom management plan and a project-based learning unit, and develop an action research proposal.

Project-Based Learning Pedagogy

UIndy TS3 emphasizes project-based learning (PBL) as a teaching methodology. PBL utilizes a student-centered approach in which students are responsible for first learning what they need to know and then finding the appropriate information in various resources to solve authentic real-world problems. The role of the PBL teacher is to facilitate learning and provide instructional scaffolding to help students develop self-directed learning skills, collaboration skills, and problem-solving skills (15, 16); thus the PBL approach integrates multiple 21st century skills including life and career skills (17). Incorporating PBL into the STEM curriculum has been shown to improve student achievement in math and science (18). Comparison of PBL to traditional classrooms indicates that PBL favors long-term knowledge retention and enhances performance skills (19). PBL students performed better on tests in terms of academic achievement and were also more successful in integrating knowledge, interpreting information, and making better conclusions than students in traditional classrooms (19, 20, 21).

TS3 candidates experience PBL through their coursework and develop, teach and share a PBL unit in their content area. Our experience has shown that schools are actively seeking teachers who can step into classrooms with a knowledge of and ability to teach using PBL, and our candidates have been hired specifically because they can incorporate PBL into the curriculum. Four of our candidates have been recruited to teach in two different New Tech schools to immediately implement this pedagogy.

Pre-Service Support

Candidates have multiple layers of support throughout their urban clinical residency. First, each candidate is mentored for the entire year of preparation by a specifically selected CMT. As previously stated, these CMTs are master teachers who have demonstrated excellence in their content area in teaching and in mentoring. High quality CMTs are identified by school administrators and by the CFs within each school. These are teachers who have been in the school a minimum of three years, have had satisfactory evaluations, and in many cases are teacher leaders within the school. In addition, feedback from candidates and the program's clinical coordinator, based on interactions with and observations of the CMTs, provides additional data for determining whether or not a CMT is invited to continue their work with future cohorts.

Program leaders and CFs work together to match candidates with CMTs based on the CMT's content area expertise and on personal characteristics of the CMT and candidate. To facilitate this

process, candidates are interviewed and complete a style and temperament questionnaire that asks the candidate to elaborate on his/her organizational and time management skills, conflict resolution style, feedback preferences, and personality traits. The aforementioned factors are all taken into consideration when matching candidates with a CMT with the intention of developing an effective mentor-mentee team that meshes with regard to personality and style.

Candidates are also supported within the district in which they are completing their urban clinical residency by a CF, an accomplished science or math teacher who has been identified by school and district administrators to serve as a program leader within their school district for UIndy TS3. The program also employs a Clinical Coordinator at the university who serves as another layer of support to monitor and assist each candidate's progress and who works directly with CMTs and CFs in their support of candidates. Finally, a UIndy TS3 program coordinator monitors each candidate's progress throughout the program. These multiple layers of support, including dedicated and approachable UIndy TS3 faculty, are designed to ensure that candidates are progressing through the program as expected and to enable proactive and "just in time" interventions with supports, strategies and tools to help each candidate succeed.

In-Service Support

Once candidates are hired in a high-need school, UIndy TS3 continues to support their development as highly effective secondary STEM teachers who can positively impact student engagement and achievement. This is accomplished by providing two years of UIndy TS3 mentoring, which serves as an extension of the urban clinical residency. The University of Indianapolis has had experience in developing and implementing two other new-teacher mentoring programs (our traditional MAT from 2003-2006 and our WWITF program from 2010-2017). These experiences positioned us to provide accessible and effective early support for our UIndy TS3 candidates. In a study of beginning math and science teachers, participants reported that assigned mentors were the greatest source of support (22) and candidates with high levels of support were more likely to remain in high-need schools beyond program requirements (6). Mentors also help novice teachers acquire skills that contribute to their teaching efficacy which also contributes to their retention (14).

Mentors represent the critical point of contact for support of new teachers. Thus, candidates are required to participate in the mentoring program. Each candidate is assigned a content-area mentor, a practicing or retired master science or math teacher, who maintains regular contact with that candidate via in-person observations and/or through various technologies. Charlotte Danielson's *Enhancing Professional Practice: A Framework for Teaching* (23) provides the framework for the mentoring sessions. Candidates also participate in two Saturday sessions per semester that feature workshops and critical conversations around pedagogy, content, successes, and challenges.

Throughout the two years of required mentoring, the UIndy TS3 faculty and staff remain in regular contact with the leaders of the schools that have hired program graduates. Those school leaders receive a letter describing the candidate's required mentoring component as a UIndy TS3 graduate and are invited to share concerns and opportunities with the candidate's mentor. In addition, the letters sent to school leaders request their participation in responding to progress report requests so that the UIndy TS3 faculty and mentors can stay apprised of the support each candidate needs. Progress reports are based on Danielson's framework components and are requested three times per academic year. Progress reports are shared with candidates and their mentors.

Program Leadership

The UIndy TS3 program operates seamlessly with a division of labor across several university faculty members and discipline areas, who each manage different program activities and components. The leadership is structured as follows:

The TS3 Coordinator: The TS3 Coordinator is a faculty member in the School of Education. She has extensive expertise in STEM teacher education, including state requirements for licensure. The TS3 Coordinator works with the graduate admissions team to market and recruit for the program; facilitates the selection and admissions process; works with the financial aid office to ensure the candidates understand and meet their financial responsibilities and responsibilities to other stakeholders; works with the SOE chair to facilitate course scheduling and staffing; coordinates with school district partners to establish clinical residencies for candidates and recruit and employ CMTs and CFs with the appropriate credentials; teaches the program's seminars; assists candidates in their job search; communicates with employers regarding the program and its expectations of candidates; works with the external program evaluator; and participates in curricular redesign based on evaluation and feedback data.

The PBL and Mentoring Leader: This faculty leader is in the School of Education. She is an expert in project-based learning and leads the co-taught Project in Science/Math Pedagogy course; manages the post-induction mentoring program; and participates in curricular redesign based on evaluation and feedback data.

The Content Faculty: These faculty leaders are in the Shaheen College of Arts and Sciences, with one faculty member from each licensure area (Chemistry, Biology, and Math). These faculty members co-teach in the Project in Science/Math Pedagogy course; participate in admissions decisions; conduct classroom observations of pre-service teachers; assess the content qualifications of the candidates' lessons; and participate in co-planning of programmatic initiatives and curricular redesign based on evaluation and feedback data. One of the content faculty members also oversees the program budget; another collaborates with Marketing to develop and disseminate marketing materials.

Results of UIndy TS3

Retention Data

Numerous sources describe the growing teacher shortages and concerns with teacher retention as summarized by Sutchter, Darling-Hammond, and Carver-Thomas (3). Evidence of our ability to provide support mechanisms to ensure that our graduates become highly effective STEM teachers in high-need schools who are able to fulfill their teaching commitment can be found in data from our clinical residency teacher preparation program. Our current clinical residency program requires graduates to teach for two years in a high-need school and to participate in UIndy-provided mentoring for two years. In the past nine years, we have graduated 87 new STEM teachers and followed their progression in their teaching career. The retention rate for each cohort and our average

retention rate across eight cohorts is shown in Table 1. Our overall three-year retention rate of 93% compares favorably to the three-year retention rate of 87.7% reported by the Beginner Teacher Longitudinal Study (BTLS) for public school teachers from 2007-2010 (24).

Table 1. University of Indianapolis Clinical Residency Placement and Retention Rate Data after Three Years of Service

<i>Cohort's first year of teaching</i>	<i>Percentage of licensed candidates teaching</i>		
	<i>Year 1</i>	<i>Year 2</i>	<i>Year 3</i>
2010-2011	100	93	80
2011-2012	100	100	93
2012-2013	100	100	100
2013-2014	100	100	100
2014-2015	100	100	83
2015-2016	100	100	100
2016-2017	100	89	*
2017-2018	78	*	*
2018-2019	100% placement*	*	*
Average Retention Rate	97%	97%	93%

* Retention data not available at time of publication; therefore not included in average retention rate calculations.

Program Impact on Candidates and CMTs

Both the impact of the residency on the candidate and the effect of the candidate's residency on the CMT were evaluated by an external evaluator using anonymous focus groups and surveys. All candidates stated that classroom management was the greatest challenge that they each faced during the year; however, they gained proficiency by being embedded in the classroom, co-teaching, and observing the CMT modeling classroom management on a daily basis. Candidates observed that students took advantage of teachers who didn't care, but, as one candidate stated, "really responded well to engaged teachers who cared about their students." Another candidate reflected, being in "one classroom for the entire year, with our teaching responsibilities scaffolded over the year was a huge support for learning how to teach." Candidates also noted that visits to other schools were a critical part of their experience. One candidate summarized, "Seeing other schools gave us a sense of different schools and the difference between charter schools and public schools, as well as of different kinds of teachers and students, and the school cultures."

To assess the effect of the candidate's residency on the CMT, the ways in which mentoring a candidate benefited the CMT and impacted their existing STEM teaching practices, including whether CMTs adopted new instructional methods from the candidates, was evaluated. CMTs provided feedback to the external evaluator. All CMTs stated that the candidates participated in weekly faculty meetings, received school and district professional development, and attended the state-wide science teachers' conference. Many candidates also attended athletic events and other extracurricular activities. One CMT stated about her candidate, "Her classroom management got stronger in the second semester when she was in control of the class. Co-teaching or taking over a

day or two was hard and she had to just figure it out as she went. She initially struggled with pacing and time management of the class, but she got much better as she gained experience and confidence teaching.” Other CMTs added, “That’s something that this program does so well – match[ing] the personality of the candidate with the CMT – and good co-teaching relationships require that match” and “We had very open lines of dialogue. She felt comfortable asking questions and checking her answers. We communicated regularly, both in-person and with text messages and using google docs to share materials back and forth. She felt she could ask me anything. We had sit downs after observations of lessons and talked through things together. She was always comfortable taking my advice and my suggestions for improvement.”

The candidates also enriched the CMTs’ professional practice. One CMT stated, “She did a couple of labs that I really liked and her PBL was fantastic, just phenomenal! Her PBL is something that I will definitely use a lot of in my own teaching of that content next year.” Another added, “I will definitely use some of the technology she used, like having the students use Google SketchUp with three-dimensional shapes. I will definitely incorporate that tool in my lessons.” One CMT, who also serves in an administrative role, commented, “Every time I have a candidate in my classroom, I learn something new about my own approaches, whether with the students or with the candidate. I am a department head and in my eleventh year as a teacher, and it is a good reminder of what a new teacher goes through.”

Program evaluation results clearly showed that both candidates and CMTs benefited from the clinical residency model of our teacher preparation program. These preliminary findings and others will contribute to the knowledge of teacher education MAT programs throughout the country, and will guide other universities as they consider implementing STEM MAT programs that include clinical residency and mentoring components.

Progression and Leadership Positions of TS3 Graduates

Results from the confidential surveys of administrators who have employed our graduates, along with the fact that their contracts are renewed, indicate that our graduates are successfully meeting expectations as effective STEM teachers. Their professional accomplishments also highlight this fact. For example, ten program graduates have been recipients of school, district, and state teaching awards. In addition, fourteen graduates have taken leadership positions in the school and state education systems, including serving as: CMTs for TS3 candidates’ clinical residencies (five program graduates); department and team chairs (six program graduates); science curriculum coordinators (two program graduates); and the State of Indiana science coordinator (one program graduate). Furthermore, three of our program graduates have also completed a principal preparation program.

Our program graduates continue to serve UIndy and the teaching profession. They contribute to UIndy by developing evaluation rubrics for use in the TS3 program, by providing Saturday professional development for new program graduates, and by reviewing outcomes projects for MAT candidates. All eighty-seven program graduates have also presented at professional organization conferences and one graduate has two peer-reviewed publications on chemistry education.

Lessons Learned

Collaboration

The long-term UIndy School of Education/Shahen College of Arts and Sciences collaboration in our teacher preparation programs has taught us some important lessons on how to closely link university coursework to clinical practice and how to develop strong collegial relationships between

program faculty (25). Faculty collaboration is essential to the urban clinical residency model. This collaboration must include campus departments and units, along with partners at clinical sites. UIndy created policies and procedures to nurture this sort of collaboration to ensure the success of our candidates and programs, and some lessons learned are described here. First, in our curriculum development work, it was imperative to recruit team members (both education and content faculty) who were wholly committed to the urban teacher residency model and who were willing to rethink curriculum to address challenges in creative ways. Second, engaging the university and district clinical faculty in regular program faculty meetings, which included planning for curricular redesign and co-teaching, as well as appropriately compensating individuals for their time, was critical throughout the program development phase. Third, evaluation data and stakeholder feedback was crucial to reflectively and iteratively review and update the curriculum on an annual basis. Fourth, space was created in the curriculum devoted entirely to responding to candidates' needs in the clinical setting, such as a clinical seminar with a schedule flexible enough to adjust for individual and cohort needs. Finally, strong partnerships demand ongoing attention, which requires a program coordinator to direct these tasks and provide oversight.

Recruitment and Marketing

Recruitment activities and marketing strategies must be designed to target specific potential candidates and populations. Our clinical residency teacher preparation program transitioned from the nationally-established Woodrow Wilson Teaching Fellows Program to our locally-managed TS3 program supported by a 5-year NSF Robert Noyce scholarship grant in 2017. In this transition, the marketing responsibility shifted to the TS3 program leadership team, and our faculty collaborated with graduate admissions and marketing staff to develop a website (26) and marketing materials for the UIndy TS3 program (27). Our recruitment efforts target our own and other universities' current upperclassmen students and recent college graduates, along with career changers. Our recruitment materials and strategies include postcards, posters, email blasts, and face-to-face informational meetings. We have made a particular effort to identify candidates from underrepresented groups by sending a personal letter along with program materials to targeted chemistry, biology and mathematics professors at historically black colleges and universities (HBCUs), asking them to share the information with and recommend the program to students they think would be great STEM teachers. One of the strongest indicators for a student to pursue a career in education is a recommendation from a respected teacher (28, 29). Thus, another opportunity we have identified in our recruitment process is to enlist the support of our own colleagues – the UIndy STEM content faculty – to help identify and encourage students to pursue a career in education. We have also successfully recruited career changers who have initiated applications to our program. However, gaining access to human resources departments at local science and technology industries has been challenging. Since the private sector technology workforce is in constant flux, this should be a rich source of candidates for our teacher preparation program if we can find an effective way to reach this population.

Program Leadership

Division of labor is key to effective management of a STEM clinical residency teacher education program. Our TS3 program has multiple facets, including, but not limited to: teaching methodologies and education content, three content areas (Chemistry, Biology, and Math), laboratory safety, clinical experiences and residency placements, and mentoring. These components

(which take place both on-campus and in our partnering districts) need to be woven together into a powerful, streamlined, and comprehensive one-year masters degree leading to licensure. Due to the integrative nature of our clinical residency teacher preparation program, it is best managed by a partnership of education and STEM content faculty, each with expertise in different areas. While the full program team includes university faculty, mentors, and faculty and administrators in partnering districts, having a smaller core leadership team facilitates communication and collaboration.

Conclusions

The University of Indianapolis Teach (STEM)³ (TS3) clinical residency teacher preparation program is highly effective and includes multiple layers of support, including a clinical residency with clinical mentor teachers and clinical faculty who serve as university supervisors, integrated and scaffolded university coursework with pedagogical training in effective teaching strategies including project-based learning, clinical seminars and classroom observations, and two years of in-service mentoring. The recruitment and collaboration of program faculty, from the School of Education, the Shaheen College of Arts and Sciences, and the partnering districts, was found to be critical to effective curriculum development and program management, and our collaborative, reflective, and iterative curricular innovation process has worked well to fine-tune the program over the course of its development and maturation. Support by university administrators has also been vital to the program's success. Evaluation and numerical retention rate results indicate that candidates are well-supported in their high-need classrooms by the TS3 program. External evaluation results also showed that the clinical mentor teacher's practice is enriched by having the candidate serving as the full-time instructor in the classroom, as the candidate imports new teaching methodologies (such as project-based learning) and technologies to the classroom. School administrators are also positively impacted by interacting with the candidates, both by keeping apprised of the struggles of new teachers and by learning new ways to engage students. The efficacy of UIndy TS3 is proven by our 100% placement rate, long-term retention of the program graduates, and their recognition as teacher leaders.

Acknowledgments

The authors gratefully acknowledge the support of the National Science Foundation through a Robert Noyce Teacher Scholarship Program grant (NSF DUE #1660653).

References

1. Cross, F. *Teacher Shortage Areas Nationwide Listing 1990-1991 through 2017-2018*; U.S. Department of Education Office of Postsecondary Education: Washington, D.C. 2017. Retrieved from: <https://drive.google.com/drive/folders/1bVuDGXaC22dtlHOPV6nhgZCNRXJdM63h> (accessed February 8, 2019).
2. Castro, A.; Quinn, D.; Fuller, E. *Addressing the Importance and Scale of the U.S. Teacher Shortage*; University Council for Educational Administration Policy Brief, January 2018. Retrieved from: <https://eric.ed.gov/?id=ED579971> (accessed February 8, 2019).
3. Sutchter, L.; Darling-Hammond, L.; Carver-Thomas, D. *A Coming Crisis in Teaching? Teacher Supply, Demand, and Shortages in the U.S.*; Learning Policy Institute: Palo Alto, CA, 2016. Retrieved from: <https://learningpolicyinstitute.org/product/coming-crisis-teaching-brief> (accessed February 8, 2019).

4. Vilorio, D. *STEM 101: Intro to tomorrow's jobs*; Occupational Outlook Quarterly, Bureau of Labor Statistics, Spring 2014. Retrieved from: <http://www.bls.gov/careeroutlook/2014/spring/art01.pdf> (accessed February 8, 2019).
5. Ingersoll, R.; Merrill, L.; May, H. Retaining teachers: How preparation matters. *Educational Leadership* **2012**, 69 (8), 30–34. Retrieved from: <http://www.gse.upenn.edu/pdf/rmi/EL-May2012.pdf> (accessed February 8, 2019).
6. Kirchhoff, A.; Lawrenz, F. The Use of Grounded Theory to Investigate the Role of Teacher Education on STEM Teachers' Career Paths in High-Need Schools. *J. Teach. Educ.* **2011**, 62 (3), 246–259.
7. Smiley, A.; Drake, J.; Sheehy, C. Blazing a New Path: Collaborating Towards Best Practice in Urban Teacher Education. In *Yearbook of Urban Learning, Teaching and Research*; Allison, B., Berghoff, B., Eds.; American Educational Research Association: Washington, DC, 2010; pp 4–16.
8. Lee, J.; Stickney, K.; Latham, K.; Sachs, D. An Interdisciplinary Approach to Project-Based Learning in a STEM Content & Methods Class: Collaboration Between School of Education and College of Arts and Sciences Faculty. Paper presented at the annual conference of the National Science Teachers' Association, Indianapolis, IN, March 2012.
9. National Council for Accreditation of Teacher Education. *Transforming Teacher Education Through Clinical Practice: A National Strategy to Prepare Effective Teachers. Report of the Blue Ribbon Panel on Clinical Preparation and Partnerships for Improved Student Learning*; NCATE: Washington, DC, 2010. Retrieved from: <http://ncate.org/~media/Files/caep/accreditation-resources/blue-ribbon-panel.pdf> (accessed February 8, 2019).
10. American Association of Colleges for Teacher Education. *The Clinical Preparation of Teachers: A Policy Brief*; American Association of Colleges for Teacher Education: Washington, DC, 2010. Retrieved from: https://coe.uni.edu/sites/default/files/wysiwyg/AACTE_-_Clinical_Prep_Paper.pdf (accessed February 8, 2019).
11. Berry, B.; Montgomery, D.; Snyder, J. *Urban Teacher Residency Models and Institutes of Higher Education: Implications for Teacher Preparation*; Center for Teaching Quality: Carrboro, NC, 2008. Retrieved from: <https://files.eric.ed.gov/fulltext/ED503644.pdf> (accessed February 8, 2019).
12. Solomon, J. The Boston Teacher Residency: District-Based Teacher Education. *J. Teach. Educ.* **2009**, 60 (5), 478–488.
13. Bodur, Y. Impact of Course and Fieldwork on Multicultural Beliefs and Attitudes. *Educ. Forum* **2012**, 76 (1), 41–56.
14. Moseley, C.; Bilica, K.; Wandless, A.; Gdovin, R. Exploring the Relationship Between Teaching Efficacy and Cultural Efficacy of Novice Science Teachers in High-Needs Schools. *School Science and Mathematics* **2014**, 114 (7), 315–325.
15. Barrows, H. Is it Truly Possible to Have Such a Thing as dPBL? *Distance Educ.* **2002**, 23 (1), 119–122.
16. Savery, J. R. Overview of Problem-based Learning: Definitions and Distinctions. *Interdisciplinary Journal of Problem-Based Learning* **2006**, 1 (1), 9–20.
17. Kay, K. 21st Century Skills: Why They Matter, What They Are, and How We Get There. In *21st Century Skills: Rethinking how students learn*; Bellanca, J.; Brandt, R., Eds.; Solution Tree Press: Bloomington, IN, 2010; pp xiii–xxxi.

18. Gordon, P. R.; Rogers, A. M.; Comfort, M.; Gavula, N.; McGee, B. P. A Taste of Problem-based Learning Increases Achievement of Urban Minority Middle-School Students. *Educational Horizons* **2001**, 79 (4), 171–75.
19. Strobel, J.; Van Barneveld, A. When Is PBL More Effective? A Meta-Synthesis of Meta-Analyses Comparing PBL to Conventional Classrooms. *Interdisciplinary Journal of Problem-Based Learning* **2009**, 3 (1), 44–58.
20. Sungur, S.; Tekkaya, C.; Geban, O. Improving Achievement through Problem-Based Learning. *J. Biol. Educ.* **2006**, 40 (4), 155–160.
21. De Witte, K.; Rogge, N. Problem-Based Learning in Secondary Education: Evaluation by an Experiment. *Education Economics* **2016**, 24 (1), 58–82.
22. Friedrichsen, P.; Chval, K. B.; Teuscher, D. Strategies and Sources of Support for Beginning Teachers of Science and Mathematics. *School Science and Mathematics* **2007**, 107 (5), 169–181.
23. Danielson, C. *Enhancing Professional Practice: A Framework for Teaching*, 2nd ed.; Association for Supervision and Curriculum Development: Alexandria, VA, 2007.
24. Gray, L.; Taie, S.; O’Rear, I. *Public School Teacher Attrition and Mobility in the First Five Years: Results from the first through fifth waves of the 2007-2008 Beginning Teacher Longitudinal Study*; National Center for Education Statistics, Institute of Education Statistics: Washington, DC, 2015. Retrieved from: <https://nces.ed.gov/pubs2015/2015337.pdf> (accessed February 8, 2019).
25. Drake, J.; Moran, K.; Sachs, D.; Angelov, A. S.; Wheeler, L. The University of Indianapolis Woodrow Wilson Indiana Teaching Fellowship Program: Reviewing the Policy Implications of University-Based Urban Clinical Residency Programs in STEM Teacher Preparation. *Planning and Changing* **2011**, 42 (3/4), 316–333.
26. University of Indianapolis Teach (STEM)³. <http://uindy.edu/education/teaching-fellowship/> (accessed February 8, 2019).
27. University of Indianapolis. NSF Noyce Grant//UIndy Noyce Grant Results. <http://uindy.edu/education/teaching-fellowship/nsf-noyce-grant> (accessed February 14, 2019).
28. Adams, W.; Callan, K.; Ensley, D.; Covington, J.; Levine, Z.; Miller, A.; Plisch, M.; Stewart, G.; Taylor, T.; Vieyra, R. *Get the Facts Out: a User-friendly Toolkit for Changing the Conversation around STEM Teaching*; A 100Kin10 Project Team: Golden, CO, 2018. Retrieved from: <https://grandchallenges.100kin10.org/progress/100kin10-project-team-perception-of-stem> (accessed February 8, 2019).
29. Marder, M.; Plisch, M.; Brown, R. C. We Need More STEM Teachers; Higher Ed. Can Help. *Education Week* **2017**, 36, 22–24.