The optimization of school-university resources in an effort to recruit teachers of mathematics

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Abstract

Purpose – The purpose of this article is to debut a novel initiative that could potentially optimize resources that are currently constrained but, if unleashed, could help ameliorate the science, technology, engineering and mathematics teacher shortage. The initiative involves the reconceptualization of the National Network for Educational Renewal (NNER) tripartite model, which evolved from the work of Goodlad (1994a) and promotes cooperation and partnerships between the three important players responsible for preparing succeeding generations of competent teachers: PK-12 schools, university colleges of education and university colleges of arts and sciences (Roselle, Hands, Marino, Kilgallen, & Howard, 2021; Goodlad, 1994a).

Design/methodology/approach – The approach used in writing the article was narrative, offering a brief review of the various challenges that have had an impact on the national teacher shortage, particularly in the field of mathematics.

Findings – The study suggests that a reconceptualized NNER tripartite model can be implemented to assuage the devastating effects of the coronavirus disease 2019 pandemic on learning, offer support to an overworked teacher workforce and provide a possible math teacher recruitment pipeline by forming a life-giving partnership between a college of education, a college of arts and sciences, a local elementary school and undergraduate math club members.

Originality/value – This is an original application of the NNER tripartite model, particularly with math teacher recruitment in mind, and it is hoped that the model will be considered transferable to a variety of school-university contexts. However, additional study is required to explore the validity and replicability of this model.

Keywords Math teacher shortage, Science, technology, engineering and mathematics teacher recruitment, National network for educational renewal tripartite model

Paper type Practitioner paper

Optimizing school-university resources to recruit math teachers

The Need to Reimagine and Repurpose the National Network for Educational Renewal Tripartite Model: A Transitivity-Type Argument

We can all agree that education has a crucial role to play in a democratic society. More specifically, it ensures the continuity of principles, values, and institutions that support a

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democratic life. Without running the risk of being political, it is fair to say that events such as Cambridge Analytica and the Russian interference in the 2016 U.S. elections remind us that our current schooling enterprise remains the most suitable conduit through which such education should be provided. Bellamy and Goodlad (2008) argued that "no other agency in our culture is capable of or charged with this challenging agenda" (p. 566). They proceeded to outline a four-part mission for schools in a democracy: "(1) providing equal access to high quality, school-based learning for the young; (2) promoting responsible stewardship of schools and universities; (3) improving teaching and learning through pedagogy that nurtures and challenges all learners; and (4) providing students with the knowledge, skills, and depositions to become fully engaged participants in a democratic society" (p. 566). They also understood that schools cannot be trusted with such a critical mission without constant oversight or, in their own words, "vigilant stewardship" (p. 565).

The aforementioned realization gives rise to the tripartite council conceptual model of the National Network for Educational Renewal (NEER), which evolved from the work of John Goodlad (1994a) and promotes cooperation and partnerships between the three important players responsible for preparing succeeding generations of competent teachers: PK-12 schools, university colleges of education, and university colleges of arts and sciences (Roselle, Hands, Marino, Kilgallen, & Howard, 2021; Goodlad, 1994a). Although NNER is currently in a transitory state, its tripartite model continues to be relevant because if democracy is to flourish, the three aforementioned groups must at least engage in a continual dialogue "aimed at their simultaneous renewal and renewal of the education of educators" (Bellamy & Goodlad, 2008, p. 567) in response to the changing times.

Unfortunately, the NNER tripartite model, although relevant and useful, has remained somewhat impotent, even in the face of the current teacher shortage crisis. It has been applied in scholarship, with colleges of education, colleges of arts and sciences, and school-based teacher educators working and researching together in what has been deemed "simultaneous inquiry" (Roselle *et al.*, 2017). Its major role over the years has been to provide guidance to the governing body of NNER. Roselle *et al.* (2021) noted:

> This tripartite council advises the governing council on the NNER activities, conference topics, and policy statements. However, Goodlad's intent was not only for these bodies to convene at an annual NNER meeting, but instead to be fully engaged with one another in the important work of preparing educators. (p. 135)

To operationalize the NNER tripartite model, a mathematician and a teacher educator collaborated to explore how the model could be applied as a math teacher recruitment tool and as a way for math majors to involve themselves in schools and be encouraged to consider teaching as a career choice. The math majors' school involvement could also have a positive impact on the school culture and climate, offering in-service teachers an opportunity to be observers and not have full responsibility for planning and executing math lessons.

Up to this point, it certainly appears that the tripartite model has been singled out and arbitrarily targeted. Fortunately, the answer to this reasonable concern lies in the understanding of the dynamics between its raison d'être as a model and the pernicious issue of teacher shortage. Moreover, due to their shared spheres of influence, the tripartite model offers a convenient structure upon which improvement can be made in tackling the teacher shortage issue. In what follows, the authors describe the dynamics through the prism of a transitivity-type argument. Most importantly, a multilayered approach to the tripartite model could be considered a useful math teacher recruitment model.

The argument

The dire teacher shortage situation that our country is facing brings some well-deserved attention to the tripartite model. Here, we seek to establish its relevance to the issue of teacher

shortage and how it can and must be adjusted to help ameliorate the crisis. In the case of relevance, we offer the following line of reasoning, known as a transitivity property of the implication or transitivity law in propositional logic. The law states that, given propositions p, q, and r, if p implies q and q implies r, then p implies r.

According to propositional logic, a proposition or statement is a declarative sentence that can be either true or false (not both simultaneously). Two or more propositions can in turn be combined together to create new ones. For example, consider the proposition of the form "p implies q" (or equivalently, "if p, then q"); this is called the conditional of the propositions p and q or an implication. Furthermore, the implication "p implies q" is known to be logically equivalent to its contrapositive "not q implies not p". With these notions in mind, we now formalize the argument.

According to the 2022 Economic Policy Institute report, "a shortage of teachers harms students, teachers, and the public education system as a whole" (p. 2). In other words, if the school enterprise is short of teachers, then the system as a whole is not well-functioning. Also, by Bellamy and Goodlad (2008), a well-functioning system is necessary to ensure the continuity of principles, values, and institutions that support a democratic life. Here we have by contraposition that, without a well-functioning school system, the continuity of our democratic life is not guaranteed. Therefore, by the aforementioned transitivity law, we have that the issue of teacher shortage is, at the very least, a threat to our democratic life, which is the main motivation behind the inception of this multi-layered tripartite model.

For more than two decades, our nation has dealt with the pernicious issue of teacher shortages in our democratic society. Furthermore, Calkins, Wiens, Parker, and Tschinkel (2023) noted:

> Teacher shortages within the United States have been exacerbated in the wake of the COVID-19 pandemic... both [in] preexisting areas of teacher shortages—special education, bilingual education, science, and math, among others—and non-traditional areas of [teacher] shortage. (p. 1)

The tripartite model offers a pragmatic way to address the teacher shortage crisis by encouraging aspiring mathematicians to become math educators and to provide in-service teachers with additional support in creating math enrichment and remediation programs for their PK-12 students. The tripartite model can be reimagined and repurposed to include not only school and university-based teacher educators and math professors but also university math students and PK-12 students. Hence, we propound a multilayered approach to the tripartite model.

The red triangle in Figure 1 represents the current tripartite model as we know it: the intersection of the college of education, the college of arts and sciences, and school-based educators or professional development school partnerships. We propose the completion of the student-induced triangle S1-S2-S3 by adding the S1-S2 edge, which stands for possible interactions between two student groups: university students (in this case, math club members) and PK-12 students (in this case, elementary education students in an afterschool enrichment program). The aim of implementing this multilayered tripartite model is to enable university math majors to discover or rediscover their intrinsic motivation to teach by giving them opportunities to work with children in a math enrichment context. The two triangles in Figure 1 symbolize what we call the multilayered tripartite model, which provides an innovative way to apply the original model as a math teacher recruitment tool. Note that the S2–S3 edge (interaction) is currently fulfilled by preservice teachers. The S1–S3 interaction arises naturally from math majors and secondary education math majors who are taking core classes together and are members of the same math club.

Teacher shortage: the next "pandemic"

The recruitment concept implied in the multilayered tripartite model is critical because we believe that the teacher shortage has become the next "pandemic" in the United States with

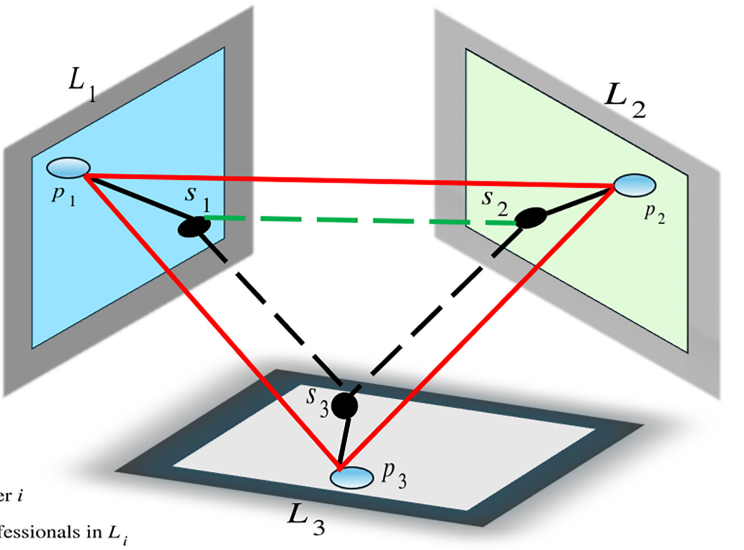

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Figure 1.
Multilayered system, where layers 1, 2, and 3 represent university colleges of arts and sciences, PK-12 schools, and university colleges of education, respectively

recruitment and retention strategies at the center of the crisis. This should not come as a surprise, and yet, as with the pandemic, we find ourselves unprepared to face the challenges of teacher recruitment to fill the numerous nationwide vacancies. This crisis means that education preparation programs (EPPs) must become increasingly innovative in generating recruitment strategies and optimizing resources shared with school partners. We are also battling excessive teacher attrition rates, which should spur school districts to begin exploring and implementing innovative retention strategies.

A National Public Radio (2022) broadcast noted:

> The National Education Association [NEA] estimates [that] there's a shortage of roughly 300,000 teachers and staff across the U.S. The teacher shortage is particularly pronounced in rural school districts, where the need for special education teachers and STEM [science, technology, engineering, and mathematics] teachers is high.

The aforementioned report is consistent with a study conducted by the Learning Policy Institute (Podolsky, Kini, Bishop, & Darling-Hammond, 2016), which predicted a shortage of 316,000 by 2025. Additionally, Walker (2022) contends, "A national survey in January found that two-thirds of teachers said they were burned out and 55% thought they would leave the profession sooner than they had planned" (cited in Darling-Hammond, p. 14).

There has been a math teacher shortage for several years, with many states declaring mathematics to be a critical teacher shortage area. The Connecticut Teacher Shortage Areas Report, 2020–21 (Connecticut State Department of Education, 2020–2021) states the following:

> Mathematics remains an essential component of STEM education throughout a student's career, yet Connecticut has difficulty recruiting and retaining mathematics teachers... All in all, Front Line Education's 2021 survey reveals that staffing shortages in secondary math represent the third-leading shortage category, behind only Special Education and substitute teacher staffing. (p. 5)

In a U.S. Department of Education press release on September 27, 2022, U.S. Secretary of Education Miguel Cardona noted, "We are treating our efforts to recruit, prepare, and retain a talented and diverse educator workforce with the same level of urgency we brought to reopening our schools during the height of the pandemic" (p. 1). The same press release stated the following:

> The National Center for Education Statistics' latest survey results on public school experiences with COVID-19 show that, as of August 2022, 53 percent of all public schools reported feeling understaffed entering the 2022–23 school year, and 69 percent reported too few candidates as the biggest challenge to hiring teachers. (p. 1).

To demonstrate the more localized nature of the teacher shortage, we have included a memo from the state's education commissioner, Charlene M. Russell-Tucker, on behalf of the Connecticut State Board of Education on July 13, 2023, indicating that the Connecticut State Department of Education "has identified 11 certification endorsement shortage endorsement shortage areas this year based on a demonstrated lack of qualified certified educators in certain subject areas" (p. 1). She went on to contend that "filling vacancies with certified teachers in these areas is an urgent need for Connecticut's students, especially in the four priority shortage areas (Mathematics, 4–12; Science, 4–12; Bilingual Education/TESOL, Pre K-12; and Special Education, Pre K-12)." The purpose of this article is to debut a novel initiative that could potentially optimize resources that are currently constrained but, if unleashed, could help ameliorate the STEM teacher shortage.

How did we get here? The pandemic and other factors

According to Long (2022), senior writer of neaToday (a publication of NEA), "pre-existing educator shortages, made worse by the pandemic, have turned each school system into a precarious house of cards." In her interviews with teachers and administrators, she learned that not only were superintendents, school principals, and paraeducators abandoning their regular duties to substitute teach, but that schools were closing because they could not staff classrooms with educators. The NEA president, Becky Pringle, is quoted in Long's (2022) article as saying, "Even more educators are leaving the field, and many are leaving mid-year. The worst case scenario is becoming a reality. There is literally not enough staff to keep schools open." In fact, there are 567,000 fewer experienced and highly trained teachers in American public schools today than in 2019 (Jotkuff, 2022).

According to a Brookings Institute commentary (Kuhfeld, Soland, Lewis, & Morton, 2022), in the fall of 2021, the grade 3–8 math students' average test scores dropped 0.20–0.27 standard deviations (SDs) in one year compared with their age peers. It states, "For context, the math drops are significantly larger than estimated impacts from other large-scale school disruptions, such as after Hurricane Katrina—math scores dropped 0.17 SDs in one year for New Orleans evacuees." Further math and reading test score data indicate that there was an even greater drop between the fall of 2020 and 2021 than between 2019 and 2020, "indicating that disruptions to learning have continued to negatively impact schools well past the initial hits following the spring 2020 school closures." Strategies and interventions to mitigate the effects of the pandemic are currently being explored, which is what prompted us to implement a multilayered approach to the tripartite model, as universities have a shared obligation to support the work that schools and communities are doing to rebuild the knowledge and skills base that has been compromised by the pandemic.

In addition to the pandemic, there are other factors that have contributed to the teacher shortage, factors that existed prior to the pandemic but have been exacerbated by it. "It can be tempting to attribute the current staffing problems to the pandemic, but the data trend lines show that the present crisis is not a temporary phenomenon. And nowhere are the problems

more acute than in math departments" (YUP, October 15, 2021, p. 2). Additionally, according to Yarrell (2022), "[p]oor working conditions within public schools have featured prominently in both creating and fueling the teacher shortage crisis" (p. 231). This includes large class sizes with limited professional support staff. Yarrell (2022) contends, "Worse still, policymakers have often exacerbated the structural inequities undergirding such conditions by underfunding public education" (p. 231). All of this means that teacher preparation programs need to reimagine their contributions to P-12 school communities. For years, school practitioners have played an integral role as school-based teacher educators in shaping the careers of preservice teachers. It is high time that the university finds a way to give back, but how do we attract young mathematicians to the field of education?

Much of the research regarding the factors that entice young people to enter the field of education has been based on those who have already decided to teach, and very little research has been conducted on how we might attract content-focused college students to consider a career in education (See, Munthe, Ross, Hitt, & Soufi, 2022). Giersch (2021) conducted an experiment at a North Carolina university with 597 non-education major students. The students were randomly assigned to three treatment groups and one control group. One treatment group was exposed to the intrinsic rewards of teaching, one to the extrinsic rewards of teaching, and one to the altruistic rewards of teaching. The control group did not undergo any treatment. The results showed that after being exposed to the rewards, all the students in the treatment groups were likelier to consider teaching as a career than the students in the control group, whose choice not to teach remained unchanged. For the treatment groups, intrinsic and altruistic rewards were the most important, followed by extrinsic rewards. This is valuable information in that it shows that we can redirect university students' career choices by exposing them to the plethora of intrinsic and altruistic rewards that a career in education can offer.

According to See *et al.* (2022), most university students have made career decisions. Thus, recruiting more math teachers requires "an approach that targets students before they make their subject choice at university" (p. 14). This is why it is important for colleges of arts and sciences to work in tandem with EPPs to catch university students in the early stages of their decision-making regarding content and career. We know that students who are disposed to study mathematics have a multitude of careers to choose from, all of which offer greater extrinsic rewards than education does – accounting, engineering, and data mining, to name a few. However, colleges of arts and sciences, together with colleges of education, can expose math majors to the possibility of teaching math by converging on math-focused groups, such as math clubs, which are open to any and all undergraduate students who are interested in math but have probably not considered a career in teaching. The hope is that once university math majors engage with children and adolescents in a learning environment, they will experience firsthand the intrinsic and altruistic rewards associated with a career in teaching.

Where do we go from here?

At our university, we are in the process of implementing the multilayered tripartite model with the goal of exposing undergraduate math (and related fields) majors to the possibility of a career in education. Last year, we reached out to the university's math club, which became the driving force behind the implementation of a school–university partnership focused on providing elementary education students with afterschool math enrichment. Under the dynamic leadership of the club's president, with support from the co-authors of this article, a tripartite model partnership was formed with a local private school in an urban school district. To assuage the devastating effects of the COVID-19 pandemic on learning and to offer support to an overworked teacher workforce, math club undergraduate students participated in the Late Day Program at the school to pilot an afterschool math enrichment program.

When presented with the aforementioned idea in the early days of the Fall 2022 semester, the math club president quickly jumped on board and sprang into action. She immediately got in touch with the director of the Late Day Program at the school, and together they laid out the framework of what has been proven to be a fruitful partnership. Pursuant to the terms of the agreement, members of the math club drove themselves to the school every other Friday to meet the schoolchildren and to provide them with math enrichment in the form of fun math activities and games. According to the club's president, their aim was to "create an environment that kind of makes the kids want to learn math and want to focus." They did this by "introducing them to fun games and icebreaker math activities such as scavenger hunts, math bingo, and competitive team math designed to boost math skills and encourage critical thinking." It did not take long for the program to become extremely popular. Every other Friday, the elementary education students looked forward to meeting with math club members and sharing with them all they had learned since they last saw each other. Moreover, it presented the club members with a unique opportunity to test, hone, and cultivate valuable skills. Albert Einstein says it best: "If you can't explain it to a six-year-old, you don't understand it yourself."

Arianna, the university's math club president, who was largely responsible for designing the learning activities that the other club members implemented, said, "Yeah, we've also created such a huge bond with the individual students, and we've seen so many faces. And every week that we show up, they're like, 'Oh, my gosh! They're here, guys! They came!" When asked what the experience taught Arianna, she said:

> I know that it's taught me really all about individuality, and I feel that's something you can learn from and take with you into any profession, whether you're a teacher, someone going into the business world, or even just attending a university.

Arianna went on to say:

> Each student and each person learns, adapts, and grows differently. You can have someone who is super outgoing and understands everything so quickly, wants to lead, and wants to learn. You have to treat them differently from how you would treat the kid who sits in a corner, who's super shy. The individuality of each student is something that any educator or person should consider going forward.

When Arianna was asked if the experience had been applicable beyond the classroom impact and if she might consider becoming a teacher, she said:

> Yeah, my whole life, I've been told that I have a teacher personality because I taught at a local preschool growing up. I was a preschool teacher's assistant, and I also used to tutor all the time. When I was asked by my math professor to go to the school, I was so excited because I loved teaching and my dad was a university professor.

When pressed to see if she might want to teach in the future, she said, "[The experience] hasn't influenced me to go into primary or secondary education, but it definitely has given me the drive to get my master's degree and try to see if I could teach math at an upper level someday." She continued, "I feel that teaching is something that's very specific, and if you have the passion and drive to do it, it's definitely something you should continue to do because, at the end of the day, you're shaping someone's future." For the math club president, the entire experience rekindled her passion for working with children, even if it did not persuade her to go into education. In the end, this experiment was a success in that the elementary education students benefitted from the math enrichment and critical thinking activities provided by the university's math club members, and PK-12 students should always be the focus of a school–university partnership.

The schoolteachers were also grateful for the added support, planning, preparation, and execution of lessons and math activities that they only had to oversee and observe and did not

have to invest time in planning, preparing, or executing. When the supervising teacher was asked about the impact of the math club members on their elementary education students, the teacher said:

> These young people come with so much energy and some really great math teaching strategies, despite the fact that many of them are not in the education program. It has given me a wonderful opportunity to observe my students and not have to be the one at the front of the room doing all the planning, preparation, and teaching.

She added:

> The young students relate really well to the young university students, and they get so excited just to interact with them. I'm hoping that this experience and the interactions they're having with university students will lead many of them to consider aspiring to eventually attend a university.

As a result of the school–university partnership, the university's math club members were given the opportunity to explore the nuances associated with teaching young children, experience the intrinsic and altruistic rewards that are salient to the teaching profession, and consider education a career option. All of this happened because the university's math club members (Arianna, president, math, business economics, and finance major; Lauren, math major; Julia, math major and education minor; Matthew, math major and education minor; and Ava, biology major) were willing to volunteer their time. Over time, this experience may resonate with the math majors who participated in the project (and with future math major participants), perhaps steering them in the direction of a career in education. Without experience of this type, math majors will have no idea if teaching is a suitable career for them.

A replicable teacher recruitment model

If the aim of schools is to actualize individuals' full potential so that they can be responsible and active participants in a democracy, then educators at every level are accountable for this enormous and challenging task (Smith, 2008). Goodlad (1994b) exhorts us by contending the following:

> Our nation [USA] is marked by a characteristic that is both interesting and frightening: We are extraordinarily patient with human folly, sometimes not paying attention until it has brought us to the edge of a precipice. Then we look down and wake up. (p. 153)

Our nation is on the "edge of a precipice" pertaining to a national teacher shortage crisis, particularly in fields related to STEM, specifically mathematics. It is the intent of the co-authors of this article to encourage that the tripartite model be considered in addressing this issue. To this end, we suggest that a multilayered approach to the tripartite model, which includes creating opportunities for university math students to engage with P-12 students, offers the potential to ignite a passion for teaching math.

Ballantyne and Zhukov (2017), Beijaard *et al.* (2004), and Boyd *et al.* (2004) (as cited in Grillo & Kier, 2021, p. 8) suggest that "[a] teacher's identity is formed and continually shaped by their experiences and context, including those before they were teachers" (refer to Figure 1). If this statement is true, then there is hope for the recruitment of math teachers in the 21st century, although we must be vigilant and strategic. As EPPs struggle to implement strategies to recruit math teachers to address the critical nationwide math teacher shortage, the EPP model – working together with the math department in a college of arts and sciences (CLAS) and applying the teaching practice to a local school – represents the epitome of what the NNER called the tripartite model: EPP + CLAS + school district = tripartite (Roselle *et al.*, 2021). When university students are given the opportunity to "teach," the hope is that they are more likely to become teachers. Even if it does not result in math club students becoming math educators right away, a seed has been planted, and one never knows when it will sprout!

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