Mentoring in the midst of *teach*HOUSTON: The Pandemic Chapter

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Abstract: This paper is the third in a series of three manuscripts under review and in press that have to do with mentoring in the midst of ***teach*HOUSTON**, an innovative urban Science-Technology-Engineering-Mathematics (STEM) teacher education program, which was developed to better meet the needs of underserved secondary students who mostly are of color. ***teach*HOUSTON** has been funded by several National Science Foundation (NSF) scholarship-awarding grants that additionally support program development. Each grant award has brought different iterations of mentoring to the surface, all of which are complementary. Our first paper (under review) demonstrates the multi-layered mentoring that takes place within the ***teach*HOUSTON** program. Our second manuscript, an in press chapter, focuses on generative mentoring; that is, the way that mentoring shoots out in all directions, with some of it being by ***teach*HOUSTON** design and other parts unspooling organically. In this paper, we dig more deeply into *the* relationships that developed and the interests shared between and among faculty, ***teach*HOUSTON** students (some being preservice teachers), teachers who are graduates of the program (***teach*HOUSTON** alumni) and secondary school students who are the ultimate beneficiaries of the urban teacher education effort. This third mentoring paper is the "pandemic chapter" of the four-year study. Meetings, interviews and focus groups conducted on Zoom allowed us to map intricate connections between and among individuals participating in two grant programs: UH-LIFE and **LEAD HOUSTON.** In this work, we conceptualize chain mentoring as the formal and informal ways mentoring played out during the global pandemic in Houston, the fourth largest urban center in the U.S., which is the site where this narrative inquiry research took place.

Keywords: STEM education; mentoring; chain mentoring; multilayered mentoring; generative mentoring; culturally responsive pedagogy

The way that mentoring has unfurled within ***teach*HOUSTON**, an innovative secondary STEM teacher education program, has been a focus of our research attention for more than four years (Craig, Evans & Stokes, in press; Craig et al., under review; Evans, Craig & Manuel, in press). A number of National Science Foundation grants awarded to ***teach*HOUSTON** at the University of Houston seeded different program innovations. Against this highly productive backdrop, mentoring emerged in multi-layered (Craig, et al., under review) (Figure 1) and

generative ways (Evans, Craig & Manuel, under review) (Figure 2).

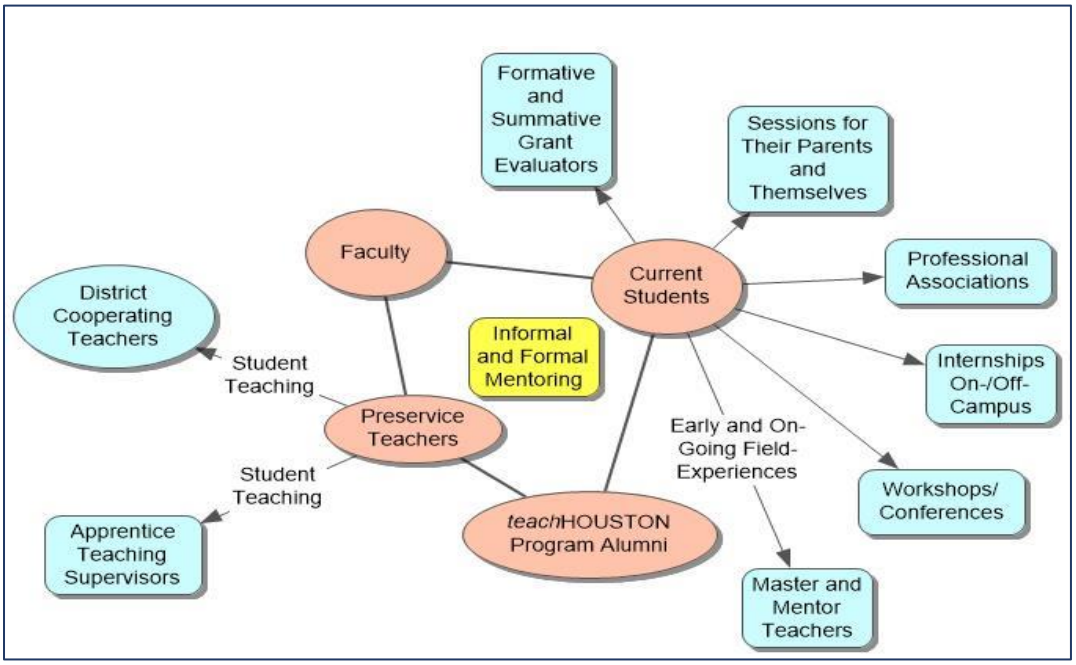


Figure 1. Multilayered mentoring

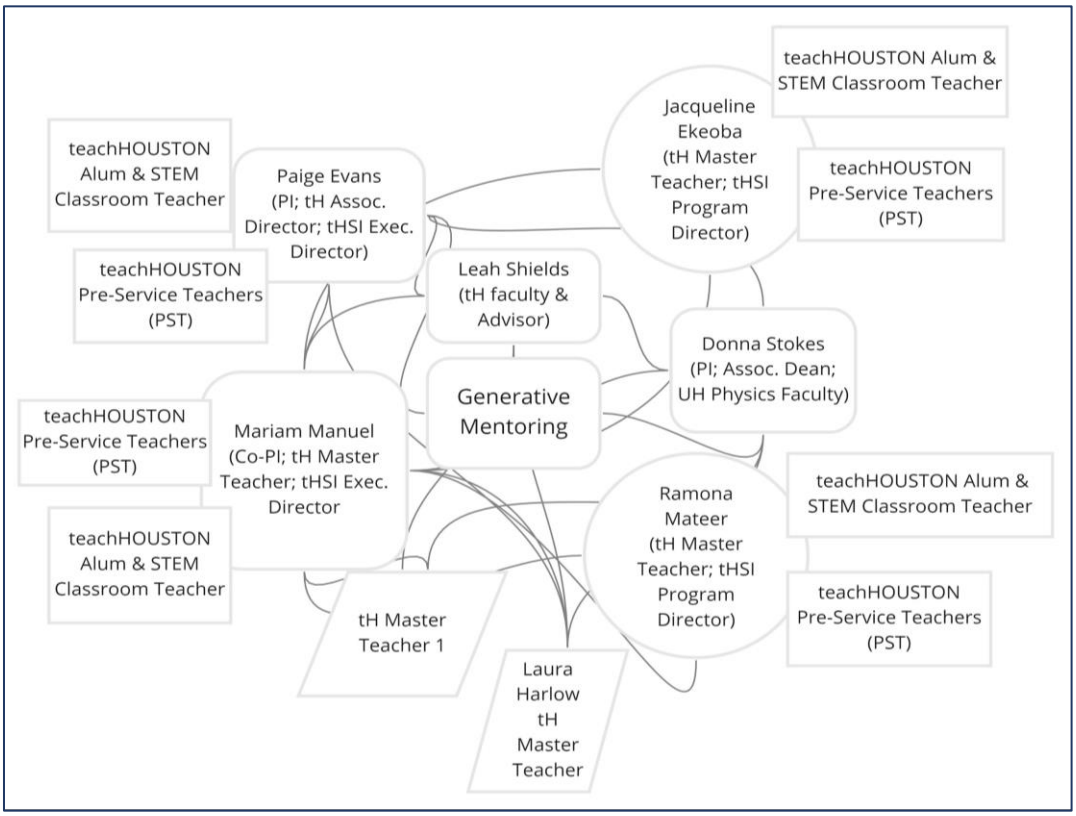


Figure 2. Generative mentoring

Then the pandemic hit. At the beginning, COVID-19 interrupted the flow of almost everything ***teach*HOUSTON** did. In response to the challenging circumstances, important modifications were made. This paper specifically focuses on how mentoring relationships developed during the Covid-19 pandemic because of the changes to the ***teach*HOUSTON** teacher education program that necessarily happened. We begin by providing background that sat behind the awarding of the scholarship grants by the National Science Foundation and introducing ***teach*HOUSTON**. After that, we present our literature review and research method followed by two rich exemplars of experience involving ***teach*HOUSTON** students who received scholarships from UH-LIFE (LIFE = Learning through Informal and Formal Experiences) (Exemplar 1) and **LEAD HOUSTON** (LEAD = Leadership through Equity and Advocacy Development) (Exemplar 2). We contextualize what happened with background from a third grant award, STEM **PARENT**, which like UH-LIFE, is nearing completion. We then name common themes that transcend the exemplars, and end by capturing and conceptualizing chain mentoring. The concept of chain mentoring complements our previous discussion of mentoring in ***teach*HOUSTON** as being multi-layered and generative. We propose that the concept of chain mentoring instantiates beneath-the-surface links and linkages within and across students and faculty that we will draw to the forefront for discussion and analysis in this paper. We furthermore will delve into the topics that these multiple knowledge communities (Craig, 1995a, 1995b, 2020; Curtis et. al., 2013) discussed in the "safe spaces" the students and faculty established for themselves. Finally, we combine all the interactions discussed in the two narrative examples in anchor figures where we show the dynamic nature and pervasiveness of chain mentoring during the pandemic year.

Before proceeding, two key concepts foundational to this research study require further explanation: the National Science Foundation and ***teach*HOUSTON**. After providing background for the National Science Foundation and ***teach*HOUSTON**, we continue with our literature review and a description of our research method. We then present our two exemplars of experience, identify key themes in them and conclude this paper with overarching understandings and possibilities concerning where this inquiry might continue to unfold as it presses toward the future.

National Science Foundation

An independent arm of the U.S. government, the National Science Foundation (NSF) supports research and education in all the non-medical fields of science and engineering. Its mission is to promote the development of science, prosperity, and wealth in the nation and to prepare for workforce needs in the future. Supported NSF proposals enable investigators to engage in innovative research and programming. The Robert Noyce Scholarship strand of NSF grants encourages STEM (Science, Technology, Engineering, and Mathematics) majors to become K-12 mathematics and science (including engineering and computer science) teachers. The grants are meant to improve the recruitment and preparation of STEM teachers in local high-need school districts. The states of California, New York, and Texas have received the most Noyce awards nationally. The University of Houston leads the way in the state of Texas with four successful grant awards since the Robert Noyce program began. Our own research on the influence of the scholarships awards on ***teach*HOUSTON** students shows that while the NSF Noyce scholarships require future work for present financial support, the incentives that students receive are "overlaid with purpose, passion, and meaning" (Goodson, 2007, p. 139) rather than "instrumentalized material rewards aimed at technical delivery" (Li, Craig, Gale et. al., 2021).

*teach*HOUSTON

***teach*HOUSTON** is a university-based secondary STEM teacher preparation program that addresses the critical need for highly qualified STEM teachers in Texas and across the nation. STEM teachers are prepared through early and on-going field-based teaching experiences and rigorous research-based instruction that integrates content and pedagogy provided by faculty members who are Master Teachers with extensive experience teaching in urban high schools. ***teach*HOUSTON** serves Houston, the fourth largest city in the United States, along with its satellite communities. Inquiry-based learning, student-centered instruction, and culturally responsive pedagogy are its distinguishing features. ***teach*HOUSTON**, a replication of the UTeach program launched at the University of Texas at Austin, addresses Greater Houston's high teacher attrition rate, particularly where secondary content area teachers (i.e., mathematics, science) are concerned. This is a pressing issue in the US and around the world. Hence, it is important to unpack how ***teach*HOUSTON** is successfully attracting, preparing, mentoring, and retaining secondary science teachers in a challenging urban environment (Craig, Evans, Bott, et al., 2017) (Figure 3).

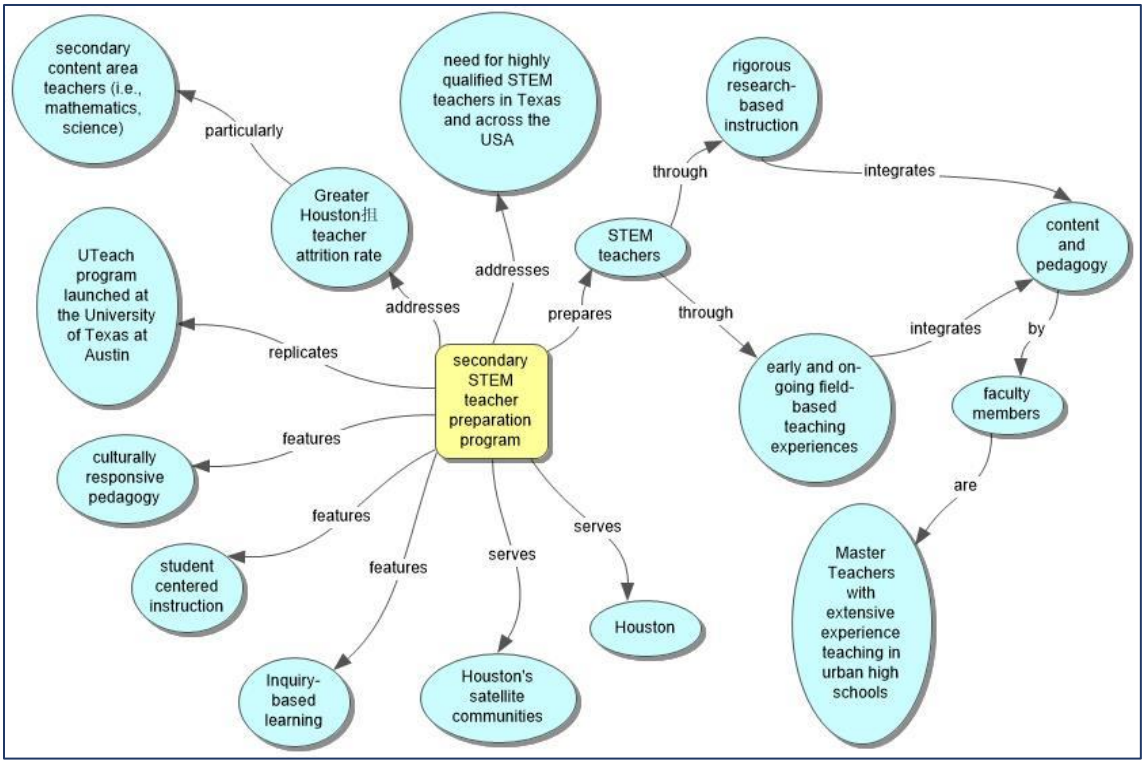


Figure 3: ***teach*HOUSTON's** distinctive features

The concept of the ***teach*HOUSTON** Master Teacher sits at the heart of the exemplary STEM teacher preparation program. More than professors, Master Teachers are role models and mentors for aspiring STEM teachers. Preservice teachers in ***teach*HOUSTON** benefit from early and ongoing field experiences provided through the program along with personal attention, guidance, and feedback delivered from the highly experienced master teachers. Hence, it is imperative that individuals holding the position of Master Teacher have been recognized for their performance in classroom teaching of STEM related subjects and demonstrate the ability to apply STEM education research-based practices in the classroom. Additionally, it is essential that they display evidence of strong advocacy for promising teaching practices along with a commitment to broaden participation in STEM for students from underrepresented minority populations through the enactment of culturally responsive teaching and inclusive classroom strategies.

***teach*HOUSTON** Master Teachers demonstrate innovation in teaching STEM and successful application of programmatic coursework. The Master Teachers lead the way in STEM outreach activities at the University of Houston and produce scholarship in the area of STEM education.

***teach*HOUSTON** began with 14 students in 2007 and now serves approximately 350 students annually. The students are 33% Hispanic, 30% Asian, 25% white, 8% Black and African American, along with Others. ***teach*HOUSTON** students teach in school districts around Greater Houston (Craig, Evans & Stokes, 2021) (Figure 4).

All ***teach*HOUSTON** program alumni, as well as the current students and faculty, are involved in informal and formal mentoring in layered ways. The students work with master and mentor teachers in early and ongoing field-based experiences; attend workshops/conferences; participate in internships on-/off-campus; belong to professional associations; attend sessions for their parents and themselves; and interact with formative and summative grant evaluators. During student teaching, preservice teachers meet with faculty, student teaching supervisors, and district cooperating teachers to design student-centered, engaging instruction appropriate for everyone, which reflects a positive climate for learning, equity, and excellence. As previously mentioned, ***teach*HOUSTON** has been described as having a multi-layered process of mentoring cultivated via knowledge community interactions (Craig, 2007; Curtis et al., 2013). That process, as earlier established, is also generative in that mentoring occurs in anticipated and unanticipated ways.

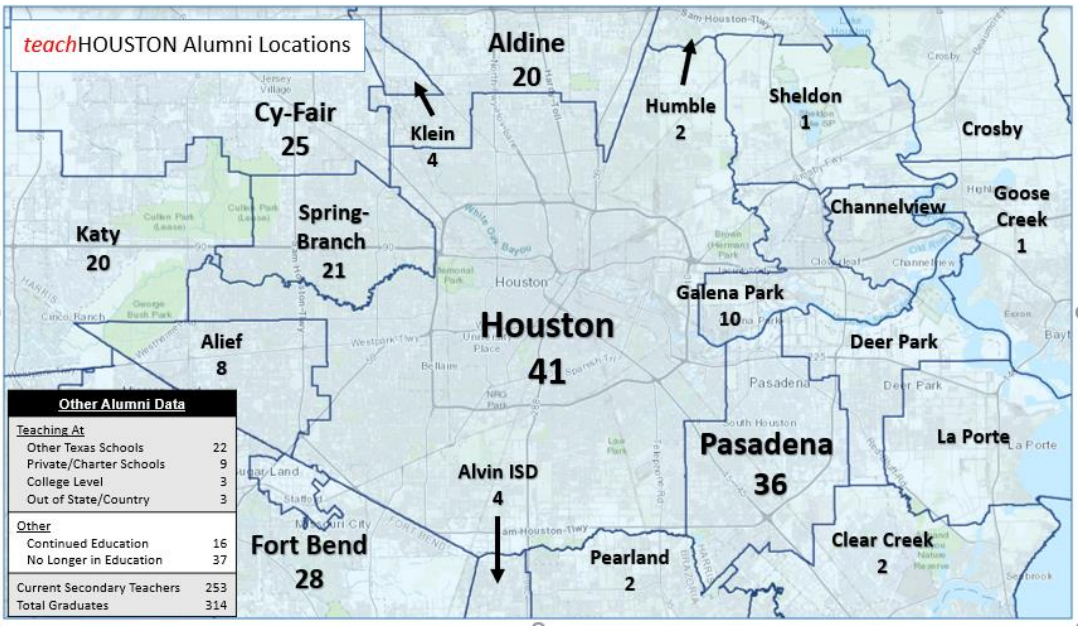


Figure 4. Graduated ***teach*HOUSTON** teachers in Greater Houston

During the pandemic, which affected both regular session and summer activities of 2020, all instruction, interactions, and informal learning activities took place online. Two exemplars extracted from two grant programs (UH-LIFE, **LEAD HOUSTON**), which are contextualized by the backdrop of a third grant (STEM **PARENT** = Scholarship Program with **P**romotion **A**nd **R**etention of STEM **E**ducation through **N**etworking **T**eam Support), will illuminate how mentoring took place during the pandemic year. Tensions and complexities of mentoring unfolding amid school-university partnerships will also be discussed (Chan, 2015; Chan & Clarke, 2014), with the profound effects of COVID-19 and social unrest also kept closely in mind.

Review of the literature

Four main concepts underpin this research: 1) knowledge communities, 2) identity, 3) best-loved self and 4) Culturally Responsive Pedagogy (CRP). Each will now be introduced.

Knowledge communities

Knowledge communities, alternately called communities of knowing, take shape as individual teachers story and re-story, and live and relive their narratives of experience in

community with one another. They are the safe spaces where one's deepest concerns and most confounding questions are shared without fear of judgment or estrangement (Craig, 1995a, 1995b, 2007). Pre-and in-service teachers have multiple knowledge communities, depending on the topics discussed. Teachers take different versions of their stories to different knowledge communities for feedback. Communities of knowing have several distinguishing features. The nine characteristics of knowledge communities described by Craig (2007) are evidenced in numerous ways across the ***teach*HOUSTON** program:

1. begin with originating events (e.g., ***teach*HOUSTON** cohort orientations)
2. enable teachers' intra/inter-school dialogue (e.g., preservice teachers with other preservice teachers, with Master Teachers, with school-based cooperating teachers, etc.)
3. allow teachers' experiences to resonate with one another (e.g., time devoted to sharing stories of experiences)
4. evolve and change (e.g., on-going program evaluation leads to continuous program improvements to promote the multi-leveled exchanges)
5. cohere around teachers' storying/restorying of experience (e.g., multi-layered mentoring, including ***teach*HOUSTON** graduates sharing their experiences)
6. fuel ongoing reflection in community (e.g., continuous feedback interwoven throughout program activities)
7. develop shared ways of knowing (e.g., STEM teacher education curriculum)
8. feature reciprocity of members' responses (e.g., exchange of stories of experience between and among varied program participants) and

9. bring moral horizons into view (e.g., culturally responsive pedagogy). (Craig, 2007)

Identity

In examining educator's actions, a glimpse into their identities (beings) begin to emerge as they uncover their 'stories to live by' (Craig, 2018; Connelly & Clandinin, 1999). In the path to becoming and sustaining oneself as a teacher, one's identity is fluid as it constantly becomes renegotiated as pre- and in-service teachers engage in new contexts (Connelly & Clandinin, 1999). Craig et al. (2018) shared how teachers' fluid identities shift based on feedback/lack of feedback from those representing the diverse perspectives they encounter as they share stories and filter new knowledge and experiences into their developing identities. As they encounter new perspectives, their professional identities as teachers are also informed by "multiple I's" (Cooper & Olson, 1996) or "multiple selves" (Orland-Barak & Maskit, 2011), such as teachers' cultural identities. With identities always in a state of flux or becoming--but never made, as Greene put it (Greene, 1995), knowledge communities catalyze continued exploration of who preservice and in-service teachers are and who they might become.

Best-loved selves

After closely reading Joseph Schwab's scholarship, Craig keyed in on his mention of a teacher's best-loved self and how it connects with the image of teacher-as-curriculum-maker rather than the image of teacher-as-curriculum-implementer (Clandinin & Connelly, 1992; Craig & Ross, 2008; Craig, 2017, 2020). For Schwab, "satisfying lives" is the ultimate outcome of education. Hence, for students to find their best-loved self, teachers must have freedom to share their passions (Schwab, 1954/1978, pp.124-125). Craig (2017) emphasized that the freedom for teachers to share their zest for teaching is not about them privileging their own propensities and desires, but rather

to

> cultivate preservice and practicing teachers who, as curriculum-makers, are mentors, guides and models, pedagogues who personally and professionally can come alongside students and accompany them in 'high adventures into the world of intellect and sensibilities.' (Craig paraphrasing Schwab, p.197)

Seligman and Csikszentmihalyi's (2000) work on flourishing showed that most humans strive to create meaningful, happy, and good lives. Norton (2020) imagines this place to be one of human flourishing--that is, we know well, do well, feel well, and be well as we enact our best-loved self. In a recent research study, Li and Craig (2019), like Li, Yang & Craig (2019), found that knowledge communities were places where teachers could safely reflect and learn as they discover and later enact their best-loved selves instead of just doing and being what the system expects them to do/be. These findings illuminate how one's best-loved self is both an individual or 'inner' journey and a social or 'outer' journey as preservice and in-service teachers learn what it means to live their best-loved self.

Culturally responsive pedagogy

Culturally Responsive Pedagogy (CRP) is a philosophy of learning that asserts the need to utilize student cultural identities and experiences as resources for student-centered instruction (Aguirre & Zavala, 2013). The approach urges educators to address student achievement gaps through the critical lens of racial and cultural inequalities (Ladson-Billings, 2009). Building upon the culture and background of students is especially beneficial to schools situated in urban areas that serve underrepresented and marginalized student populations. This philosophy of teaching calls for the design and embodiment of instruction that is sensitive towards, and informed by, students' cultural and linguistic characteristics (Gay, 2002; Irvine, 2010). CRP entails a student-

centered approach to teaching that connects content topics with the life experiences of the students being taught. CRP is grounded in the belief that all students can be successful and encourages teachers to adopt an asset-based mindset when interacting with students (Ladson-Billings, 1994).

Research method

Narrative inquiry

Narrative inquiry is a storied research method that unpacks pre- and in-service teachers' narratives of experience; that is, the stories they tell and retell, live and re-live, with the people with whom they interact. These narratives unravel in a three-dimensional space consistent with Dewey's (1938) qualities of experience. These narrative inquiry spaces involve time (past-present-future), place (context) and relationships (interactions). If all three were not present and simultaneously interacting, the research would be something other than a narrative inquiry.

Tools of inquiry

Narrative inquiry has three analytical tools: broadening, burrowing, and storying and restorying. Narrative inquirers begin by situating their studies on the broader educational ***teach*HOUSTON** urban landscape as one where mainly underserved students of color live. We also have described the background of the National Science Foundation and highlighted the number of grants the University of Houston's ***teach*HOUSTON** program has received. We also broaden this inquiry by discussing NSF's origins and different grant programs. As we move forward, we will use a second research tool: burrowing. In the sections that follow, we mostly burrow into what pre- and in-service teachers reveal over time about their mentoring experiences, their knowledge communities and their experiences as STEM (Science-Technology-Engineering-Mathematics) educators within the ***teach*HOUSTON** teacher education program. As their narratives of experience unspool, changes in their storying and re-storying, including their stances,

subtly and not so subtly take shape as their pasts-presents-futures fuse on the ***teach*HOUSTON** and Greater Houston landscapes.

Truth claims

In education and life, truth—even about the origins of the pandemic—has become increasingly contested. To further complicate matters, different kinds of truth exist: historical truth (time-ordered truth) and narrative truth (experience-oriented truth) (Spence, 1984). Recently, false truths (unsubstantiated truths) have intensified conflicts. This paper investigates students' experiences of their grant-supported ***teach*HOUSTON** STEM teacher education program in the pandemic era. We sought pre- and in-service teachers' responses to their online teaching and professional development experiences. We entered this study narratively; that is, we sought the narrative truths of their lives. However, we were not oblivious to historical truth. We also order how things happened temporally—but we favor how people storied events happening over time more.

Exemplars

The analytical devices, introduced earlier, are the building blockers we use to create narrative exemplars. Lyons and LaBoskey (2002) called for the use of narrative exemplars as a way to show that prospective and practicing teachers know and that they know that they know. Candidate exemplars, in Lyons and LaBoskey's view, provide "*concrete examples…elaborated so that members of a relevant research community can judge for themselves their 'trustworthiness' and the validity of observations, interpretations, etc.*" (Lyons & LaBoskey, 2002, p. 20, italics in original). Such exemplars have five common characteristics. They:

- capture intentional human actions that not only tell a story, but convey the developing knowledge of those involved,

- are lodged in socially and contextually embedded situations,
- draw other people into the mix as the narrative exemplar is unpacked,
- implicate people's identities,
- focus on interpretation, often including different points of view. (Lyons & LaBoskey, 2002)

We now transition to a description of our local pandemic context and our two narrative exemplars of experience: one drawn from UH-LIFE; the other culled from **LEAD HOUSTON.**

Two Exemplars of Experience

Contextualizing the pandemic

Before moving forward with our UH-LIFE and **LEAD HOUSTON** exemplars, we need to paint the pandemic backdrop within which the two exemplars of experience unfolded. When the COVID-19 outbreak struck in January 2020, countries around the world responded with action plans to treat COVID patients and curb the rapid spread of the virus. With hospitals around the world filled to overflowing with COVID patients and COVID-related deaths soaring, the World Health Organization declared COVID-19 a pandemic on March 11. Immediately, country-after-country went into lockdown, closing all non-essential businesses (e.g., restaurants, hair salons, entertainment venues, etc.) and initiating rigid travel restrictions. In the US, a state of national emergency was declared on March 13. So began the national lockdown.

As it would happen, this occurred during the University of Houston's mid-semester break when the vast majority of the university's 46,000 students were already off campus, traveling for vacation or visiting with family members. Consequently, the university's announcement of an immediate transition to on-line classes meant that many students decided to return to or remain in their parent's home during lockdown.

The pandemic chapter

The NSF-funded STEM **PARENT** (Parent = Promotion And Retention of STEM Education through Networking Team Support) program was designed to provide a multifaceted support system for STEM students (including ***teach*HOUSTON** students) with financial need. The NSF grant's components included orientations, monthly student special interest group meetings (S-SIG), mentoring networks, research placements, and a Parent Academy. S-SIG meetings engage student scholars in workshops presented by various university service centers (e.g., writing center, career services, counseling, etc.) on a wide range of topics such as writing a personal statement, course advising, managing time, health and wellness, study habits, and de-stressing techniques. The Parent Academy meetings are a non-traditional approach for engaging a parents/family learning community in conjunction with the student's academic community. The Parent Academy meetings serve as a bridge between the scholar's academics and family community by bringing both entities together through family-oriented science events to help make connections between real life, science and scientific careers as well as provide parent/supporter with resources for helping their scholars succeed as a STEM major. The S-SIG and Parent Academy meetings created opportunities for mentoring to occur between the scholars, parents/supporters and researchers in various ways, i.e., multi-layered, generative and chained, as all participants serve in some mentoring capacity.

Due to the pandemic, the S-SIG meetings and Parent Academy activities transitioned online. The meeting discussions led by PI Donna Stokes, Co-PIs Laveria Hutchison and Monique Ogletree, and the research team, included conversations about the impact of the pandemic on academics. Shortly after the start of the pandemic, social unrest centered around unjust acts against Black Americans were brought to the forefront and the research team realized that discussions on

mental and physical wellness needed to be included as well. The typical mentoring that occurred through the S-SIG and Parent Academy meetings now had to occur in the virtual environment. Despite the lack of physical presence for the students, the parents/supporters and PI team, many of the scholars were living with their parents/supporters, which allowed for an extension of traditional mentoring to occur that was more centered around support and surviving in and through the pandemic. Meetings and discussion topics were intentional and included presentations related to cultural awareness and cultural connections to health and wellness.

In mid-February 2021, almost a year into the pandemic and the US lockdown, a severe snowstorm swept the U.S., significantly adding to the strain of Houstonians and University of Houston students in particular who were already dealing with the interruption of the pandemic and social unrest on their academic and personal lives. The storm added an another layer of crisis that also factored into students' academic success. After the winter storm, a Parent Academy meeting was held which allowed the scholars, parents/supporters and research team to have a debriefing session to share their experiences of how they received and gave support to their peers and family members during this time when many had been without electricity and/or water for nearly a week. Students reported gathering around fireplaces with their families, without devices (computers, cell phones, etc.) in hand, trying to keep warm. They additionally revealed how family members slept together to survive the bone-chilling cold. During this meeting, the research team presented statistics concerning university students' depression, stress, and routines (Table 1) and offered suggestions for ways to cope. Through openly discussing these statistics, students, as well as parents/supporters, were provided with an overview of the short-term impact of the pandemic on student success and could foresee some of the long-term issues that may exist. Through sharing and reflecting, the researchers engaged the group in conversations that would help them realize the

need for support and mentoring at all levels to ensure their success in their courses. Students were able to see that they were not alone in their feelings where the pandemic plight was concerned, and their supporters gained valuable information about ways they could support them as they make important decisions that may affect their futures. For example, the University's interim grading policy during the pandemic allows students the choice of masking earned grades for courses where student performance may have been impacted by circumstances related to the pandemic, i.e., contracted COVID-19, responsible for caring for someone impacted by COVID-19, dealing with a loss of a loved one due to COVID-19, to name a few. By discussing the pros and cons of the interim grading policy, the students and the parent/supporter were able to gain a better understanding of how the use of the interim grading policy could influence their long term academic and career goals. Table 2 outlines survey statistics on university student perspectives on support and the future, therefore, demonstrating what the research team had likewise discovered within the context of the NSF STEM **PARENT** grant's Parent Academy that having these types of conversations will help STEM students academically and personally during and after the pandemic. These conversations also allowed mentoring relationships during the pandemic to continue to build in the virtual environment, resulting in stronger connections between student, parent/supporters and the research team in a more personal way, which will be beneficial to supporting the university students academically.

Table 1. Negative Impact of the Pandemic on University Students

Percentage	Nature of the Negative Impact of the Pandemic on University Students
48.14%	experience depression
71.26%	show an increase in stress
76%	have difficulty maintaining a routine
85%	indicate focusing on school and work is the most difficult

(Son, Hegde, Smith et al., 2020)

Table 2. Positive Impact of the Pandemic

Percentage	University students' perspectives on support and the future
87%	indicate that parents can support them by "spending more time with them and engaging more in conversations."
79%	feel hopeful about achieving their educational and future employment/professional goals.

(Son, Hegde, Smith et al., 2020)

The pandemic, coupled with social justice, economic and environmental crises, allowed mentoring to continue and to develop in new ways not only in the STEM **PARENT** Program, but also through the UH-Life and Houston grant programs. Now the two exemplars, each featuring a different thrust in ***teach*HOUSTON**'s program constellation, will be showcased.

Exemplar 1: UH-LIFE

Description of UH-LIFE NSF Grant

The purpose of the Noyce Program, STEM Teacher Preparation at the University of Houston: Learning through Informal and Formal Experiences (UH-LIFE), is to increase the number of highly qualified teachers, particularly those from underserved minorities, certified to teach in the critical needs areas of grades 7-12 mathematics and science in high needs schools in metropolitan Houston and across the United States through recruitment, preparation, and induction activities. Major goals include collaborating with a junior college; offering summer internships and scholarships; developing biology and chemistry inquiry courses; and creating a Noyce Professional Development and Mentoring Institute for undergraduates and graduates.

Exemplar of Experience

When UH-LIFE began, Paige Evans, the grant's Principal Investigator and Donna Stokes, the Principal Investigator of the original NOYCE grant, were the two professors that the students frequently named as influences on them. However, as UH-LIFE moved into its final years, the

students detailed a number of faculty who influenced them both inside the grant program and outside of it. These included Mariam Manuel, Leah McAlister-Shields, and Laura Harlow (who were mentioned) among others whose names we have masked. From beginning to end, the students' sense of community broadened and deepened as they more closely came to know multiple STEM instructors representing content areas ranging from physics to mathematics to culturally responsive teaching to biology to chemistry to computer science and so forth. They additionally came to know each other more fully as members of two cohorts. Two overarching points lingered with us long after the interviews and focus groups for the pandemic year were completed. They were 1) how the students could finish one another's sentences and could get inside each other's experiences on an ongoing basis, and 2) how the students were able to share vulnerabilities without judgment on the part of their peers. This was an amazing achievement for the diverse ***teach*HOUSTON** students, given the recent pandemic, US political unrest and the resurgence of hate crimes and prejudices (Auzenne-Curl & Craig, 2021; Ladson-Billings, 2020). The matters they discussed included concerns about beliefs/actions of family members with whom they did not agree, memories of being bullied as teenagers and the experience of being an under-represented female in STEM in addition to being a person of color. Still others discussed the unwarranted blaming of others and other minority groups (e.g., African American, Chinese) and beneath the surface prejudices regarding dark skin tones/light skin tones within and across races, and other sensitive topics that needed to be unpacked. Clearly, the students had discussed deep issues in their past classes and were well equipped to discuss them in the present. They additionally expressed concerns about scientism (Hyslop-Margison & Naseem, 2007; Moreland, 2018; Stenmark, 2020) and growing suspicions of scientists and their findings (Barnes, 2005; Chalmers, 2013; Jarnefelt, 2018). They acknowledged that the latter developments have made the teaching of science

increasingly challenging.

According to Paige Evans, the Associate Director of ***teach*HOUSTON**, the ***teach*HOUSTON** STEM Interactive (tHST) program, was originally designed as an on-campus face-to-face hands-on event meant for a maximum of 60 local Grade 6-9 students. However, when the pandemic struck, STEM Interactive was forced to change. Instead of cancelling the initiative altogether (which would have been the natural inclination), the faculty of ***teach*HOUSTON**, with permission from the National Science Foundation (NSF), decided to take the program to national and international scale as there was a significant number of students and teacher mentors desperately needing summer employment. In the end, 3000 Grades 6-9 students virtually attended from seven countries—with Singapore being the country furthest away. Five percent of those who enrolled were international, 11% were from other states, and the remaining 84% were in virtual attendance from places within Texas.

As one UH-LIFE scholarship student shared, "Students from all over the world tuned in. Some lived in Europe. It was a completely different time zone there…" The UH-LIFE student continued: "It was so very, very, very cool. And because it was online, we invested a lot of time in it because we could do it from the comfort of our homes and personally (by ourselves)." Another UH-LIFE student added, "We had to teach online and learn the online platform as we went along. And we did not have our peers helping us [because they were learning too]…We had master teachers like Dr. Manuel steering our online education while we were teaching others virtually." Most of the lessons involved household products that the 3000 online students could easily find in their homes.

The UH-LIFE students worked with a Master Teacher (i.e., Paige Evans, Mariam Manuel, Jaqueline Ekeoba, Ramona Mateer), each of whom worked with a Lead Teacher (a

*teach*HOUSTON alumni) and a portion of a group of 26 preservice candidates and 4 *teach*HOUSTON graduates serving as Leads. In addition, four graduate assistants were involved and the four Leads were practicing *teach*HOUSTON teachers who had been beginning teachers three years previously (Figure 5).

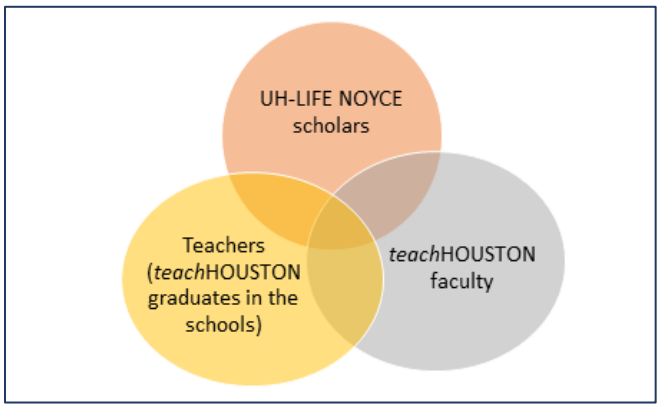


Figure 5. Relationships among Faculty, Noyce Scholars, and Teacher Graduates

tHSI Backdrop

In Summer 2020, three weeks of hands-on STEM content activities with interactive components were offered to the 3000 middle school students from June 22-July 10. Four daily Zoom lessons mostly took place with group discussions happening on Facebook as well. All of the interactions—the lessons, the videos and the assessment—remain online for use at any time. This speaks to the widespread dissemination of tHSI.

Mentoring Experiences

Working on the *teach*HOUSTON STEM Interactive (tHSI) summer initiative, UH-LIFE NOYCE scholars communicated with teachers (*teach*HOUSTON graduates in schools), along with *teach*HOUSTON faculty. Corina told us that "we [NOYCE scholars] are in relationship with them [faculty, other scholars] at the same time as we are working with students in our online classes."

In the past, we have described *teach*HOUSTON's approach to mentoring as *multi-layered*

and *generative*. It is *multi-layered* in that it includes an overarching layer of ***teach*HOUSTON** faculty support that feeds into Lead teachers with three years of experience who then ready tHSI preservice teachers who in 2019-2020 instructed 3000 Grade 6-9 STEM students who locally, state-wide and nationally participated (Figure 1). The multiple layers of mentoring include--but are not limited to--the hierarchical relationships within ***teach*HOUSTON**.

The mentoring that unfurls is also *generative*. By this, we mean that its patterns of association are both predictable and unpredictable. There are regular associations that happen, many of which follow hierarchical lines, while other vertical and horizontal associations are emergent. Overall, mentoring takes place in forward-moving (generative!) ways. We now share what the students told us in multiple interviews and focus groups, which has been verified by the faculty of ***teach*HOUSTON**.

Carmen shared that she takes "every opportunity she gets to network with students who are going through the same things that she went through." Thus, while she is in the Mathematics Group and engaging in peer mentoring there, she is also interacting with individuals in the Life Sciences Group, the Earth and Earth Sciences Group and the Engineering Design and Innovation Group as well (Figure 6).

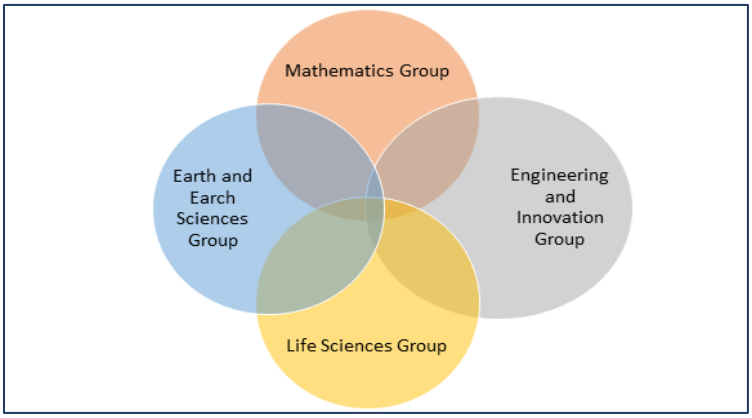


Figure 6. Carmen's interactions with multiple content groups

Martin explained that he was in the Life Sciences Group hosted by Ramona Mateer. However, he already had a previous point of contact with Master Teacher Jacqueline Ekeoba, who he also named. Where his mentoring of others was concerned, he focused his efforts on the Grade 6-9 students he taught (Figure 7).

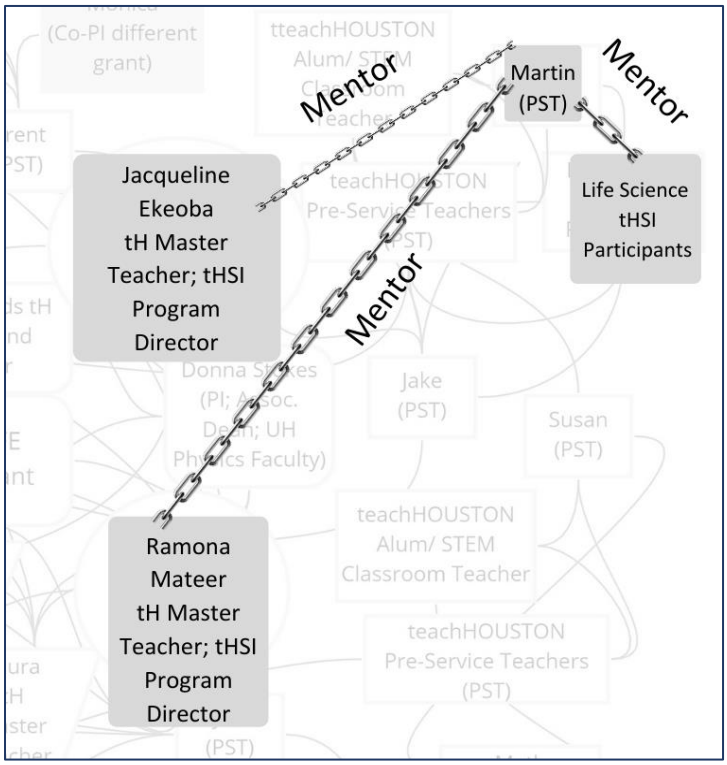


Figure 7. Martin as mentor and mentee

Other Noyce Scholars appreciated the third-year ***teach*HOUSTON** graduate teachers who virtually returned to campus to enrich the summer program. They spoke of how these four lead teachers reached out to them "to answer their questions and to mentor them in areas where they shared interests and concerns" (Figure 8).

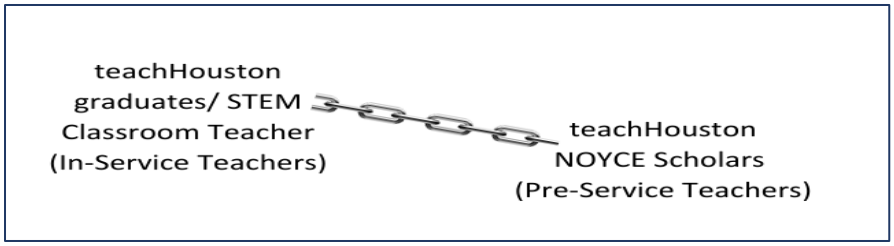


Figure 8. Preservice and In-service Teacher Mentoring

Susan, another Noyce Scholar, spoke of how she struck up a relationship with a Lead teacher who is in Science but she (Susan) is in Math. Susan indicated that Mariam Manuel (Engineering Master Teacher) was a strong influence on them. According to the students, she makes certain "they are on top of their stuff." Two students were previously in pre-med, and their parents were very upset when they moved to teaching the STEM disciplines. Dr. Manuel reached out to them--even sat one of them down on a bench--and told them of her personal story of not becoming the doctor her parents wanted. The students liked how she gave them hope for "relationships" with their parents once their disagreements were "in the rear view mirror." (Figure 9).

Laura Harlow, a ***teach*HOUSTON** Master Teacher, did a similar thing for Jake, another student who took a direction unlike what his parents expected. She presented him with options when he was certain that he could not continue on his career pathway he was on. She also invited him to be a member of ***teach*HOUSTON**, if he so desired. He continues to interact with Ms. Harlow concerning ***teach*HOUSTON** matters. Jake said, "She was his go-to Master Teacher when he exited pre-med… and has been so ever since." However, Jake also identifies Jacqueline Ekeoba, a program director of tHSI and a master teacher named earlier, as a second mentor. According to Jake, they cross disciplines but they both are interested in creative pedagogies, which is an area where he wants to continue to develop (Figure 10).

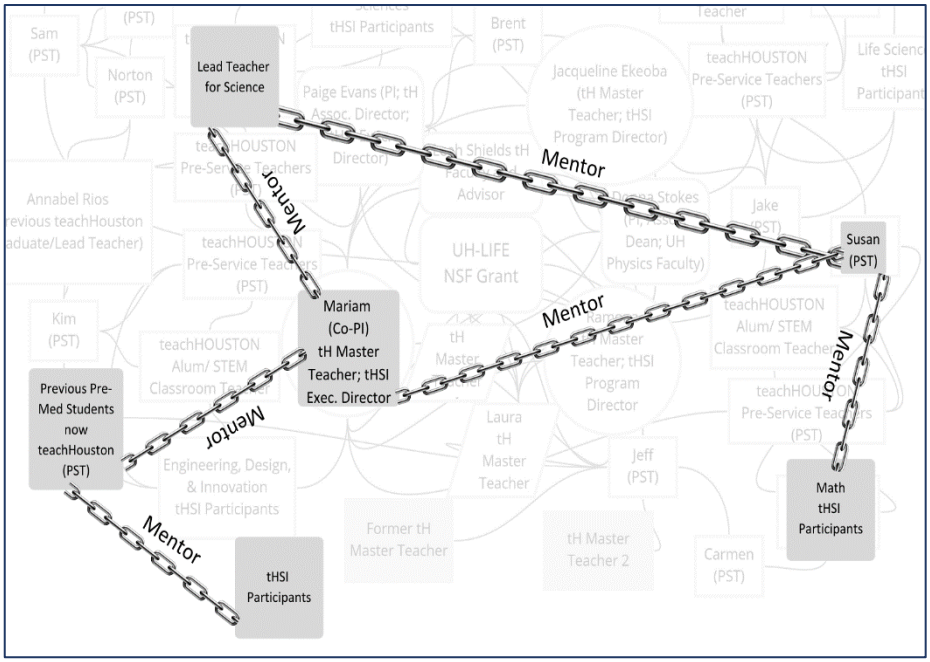


Figure 9. Mariam Manuel as mentor

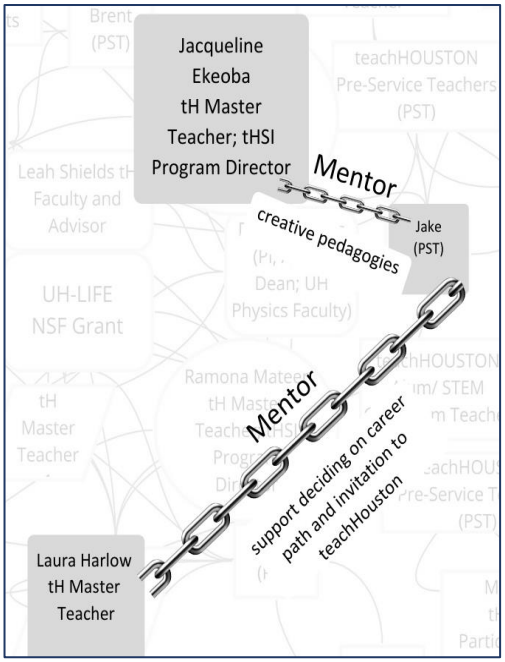


Figure 10. Jake's mentors

A further student named Brent told of his being a facilitator for another grant whose PI is Donna Stokes and Co-PI is Monique Ogletree. Brent knew both of these professors from the NOYCE 1 STEM grant in which Donna Stokes was a PI and Monique and Paige Evans were both Co-PIs. Both continue to be his mentors, along with his peer Brendan who four other students named as well (Figure 11).

Sam, another student, spoke of taking his physics questions to Paige Evans but also to his peer, Thomas, who "tries to help to explain things to [him] in a language [he] understands." Sam said it depends on what the topic is as to whether he approaches Paige Evans to mentor him or Thomas, his peer. He added that depending on the topic, there are at least five other peers he would consult. However, if the question has to do with classroom materials, he would probably go to Paige Evans, as "she is very innovative, very creative." At the end, Sam added another peer, Norton, to the list, "Because he is very, very good at professional development." Sam reconfirmed that he always checks things out with Norton—that he always asks Norton "What are your thoughts

on this? What are your thoughts on that?"

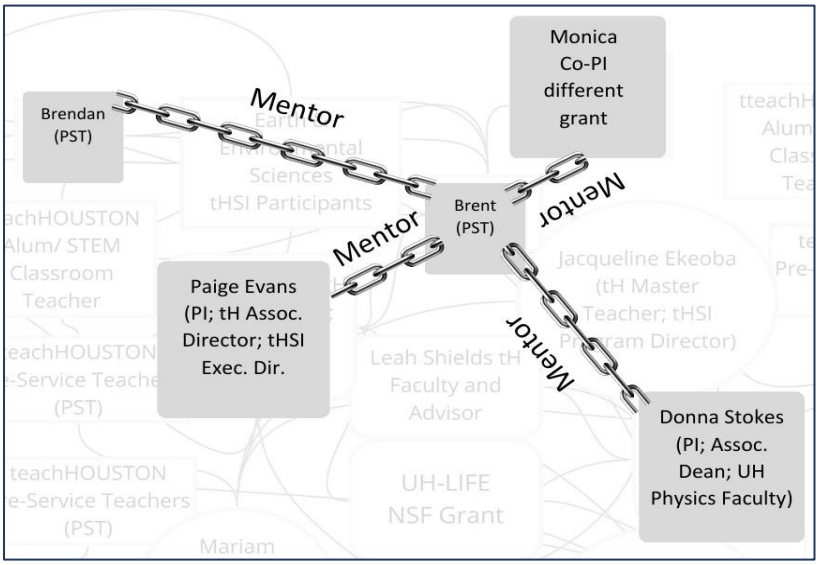


Figure 11. Brent's mentors

However, when Norton was asked to share who his tHSI mentors are he reached back in time to his first observations in the schools and a female physics teacher, Annabel Rios. He said he had contacted her several times in his preparation to student teach. He said that she has "shared lesson plans" and "talked to him…pretty frequently." He added that Rios had also helped his peer Kim as well. Norton said, "she [Annabel Rios] always takes up the torch for us" and is one of the Leads of the tHSI program. However, if his queries had to do "with creativity things," he would always turn to his peer, Brent, who is quick to pinpoint "something that is out of place."

The NOYCE scholars also pointed out that Brendan was the president of the student society and Sam was the vice-president. They would all go to both of them at one point or other concerning topics related to policy and advocacy (Figure 12).

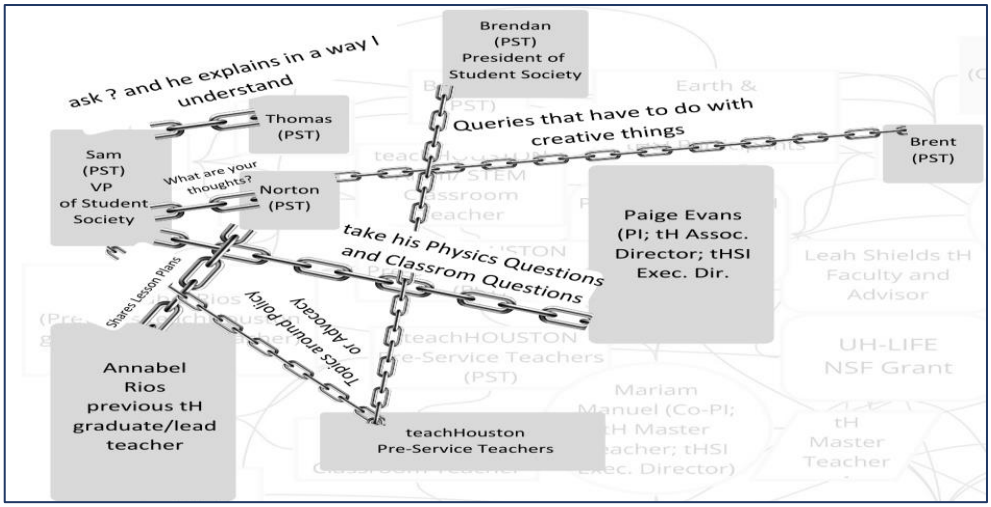


Figure 12. Sam's and Norton's mentors

A further male student, Jeff, spoke of another mentor, a lead teacher from a year ago who he considered as a ***teach*HOUSTON** mentor. Jeff additionally named four peer mentors of his own: Sam, Karen, Norton and Carmen. He added that Norton was definitely his backup person for mathematics, but if his concern was physics, he would go to his fellow students Karen or Sam. He then added his peer, Brendan, because "Brendan always keeps the ball rolling." As for matters pertaining to culturally responsive pedagogy, Mariam Manuel and Leah McAlister-Shields would be his go-to people (Figure 13).

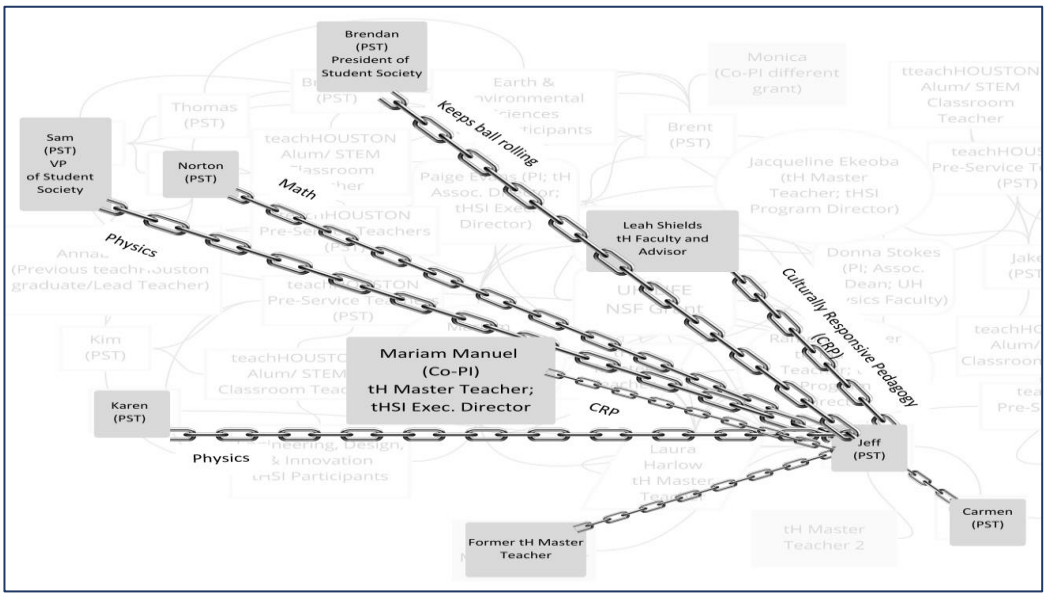


Figure 13. Jeff's mentors

Taken together, the mentoring relationships in UH-LIFE at the point in time when our field texts were gathered looked like Figure 14.

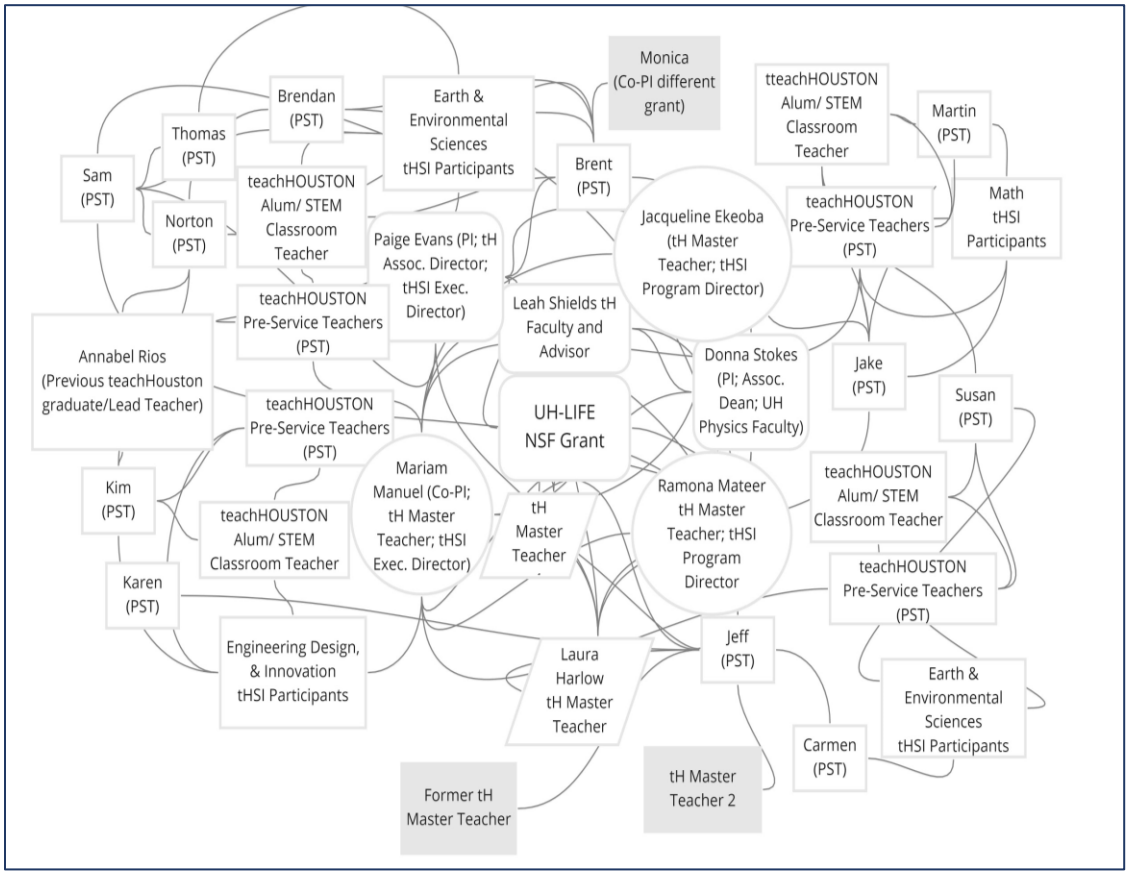


Figure 14. Chain Mentoring in UH-LIFE

Exemplar 2: LEAD Houston

Description of* LEAD Houston *Grant

In 2018, *teach*HOUSTON received a Noyce Track 3 grant, University of Houston – Leading through Equity and Advocacy Development or UH-LEAD, also referred to as LEAD Houston. This grant was designed to develop and retain secondary STEM teachers in high-needs districts through the cultivation of teacher-leadership skills. Selected teachers, also referred to as Master Teacher Fellows (MTFs), are provided with the opportunity to engage in graduate level coursework, professional development, and mentoring of preservice teachers. Upon completing their master's degrees in STEM education, the MTFs participate in professional development

seminars on topics of instructional coaching, culturally responsive pedagogy, social justice issues, and policy advocacy. Furthermore, the MTFs are regularly surveyed on their professional development requests in an effort to design sessions that are responsive to their needs. As mentor teachers, the MTFs work with preservice teachers in their field-based courses that take place prior to student teaching. As cooperating teachers, they serve as mentors to those who are completing their student teaching experience, which is a full-time, 14-week experience in high-need public schools. The MTFs offer high quality evaluation, guidance, and dialogue that enables student teachers to grow and thrive in diverse, urban schools. The special relationships formed during this integral experience remain long beyond the student teaching semester and evolve well into the first few years—the induction years—of the student teachers' careers.

Exemplar of experience

When the Noyce Track 3 Master Teacher Fellows (MTFs) introduced themselves, their ease and sense of comfort with their fellow cohort members immediately became apparent. Rory, Les, Aria, and Tom bantered back-and-forth about where they first met on campus, what they remembered about that first meeting, and when they became close colleagues as part of the *teach*HOUSTON program as LEAD Houston MTFs. Aria confirmed with an air of certainty that they have been together for three years. The others query why she is so sure. She replied that they may not remember—but she vividly recalls—that she was pregnant when she first began the program (Figure 15).

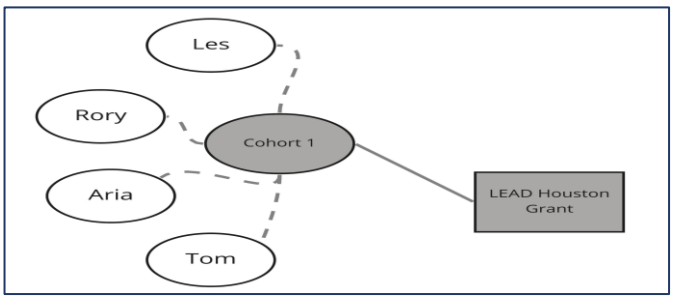


Figure 15. Growing a knowledge community

She then scooped up her three-year old toddler who nestled into her, fascinated by the picture frame photos on her mother's computer screen and glad to have her parent present to her after her mother's full day of face-to-face school teaching in spite of the pandemic underway. The truth of the matter is that all of the cohort members had just finished a day leading the STEM disciplines on their Greater Houston campuses. Becoming Noyce Fellows may have been the originating event of their blossoming knowledge community, but sharing their experiences as STEM leaders in the field formed the glue that has held their community of knowing together since that first point of contact.

Ana, Irby and Ron then joined in. They indicated—also through light banter—that they too live in a knowledge community cohort with one another. However, their micro community is not the same. Like Rory, Les, Aria and Tom, they are in Cohort 2 of **LEAD Houston**. Their joining a cohort of "like-minded individuals" (Ron's words) was also an originating event for their knowledge community within the larger **LEAD Houston** grant project/***teach*HOUSTON** teacher education grant program (Figure 16).

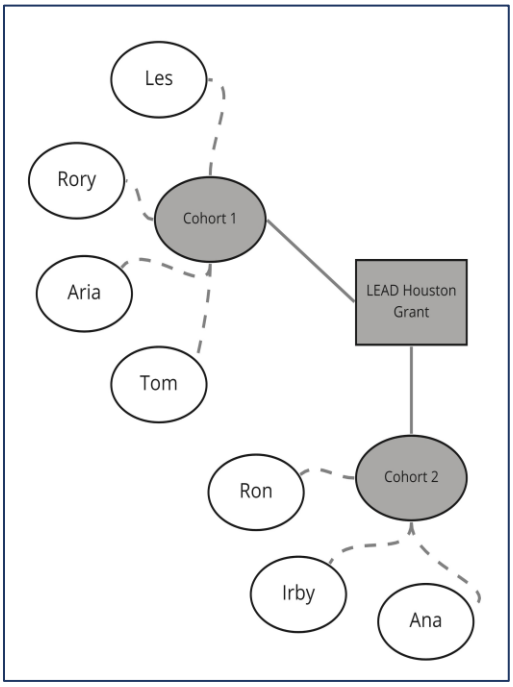


Figure 16. Interaction of micro-communities (cohorts) creates new knowledge communities

A bit later, Mary entered the conversation. She positioned herself with Ana, Irby and Ron. She added a significant detail. She proffered that she has a Bachelor's degree from the University of Houston-Downtown. She noted that Dr. Jackie Sack and Dr. Judith Quander mentored her there. This identification revealed more of Mary's background. It located her as a math education major. This is because Jackie Sack is a math education professor, and Judith Quander is a mathematics professor. The two UH-Downtown professors taught their classes together (team-taught) on their campus, thanks to their own NSF NOYCE grant, *Esprit de Corps*. Mary acknowledged her community of knowing with them at the same time as she situated herself alongside her colleagues, specifically naming Jennifer Chauvot, a Mathematics Education faculty member as her current mentor (Figure 17).

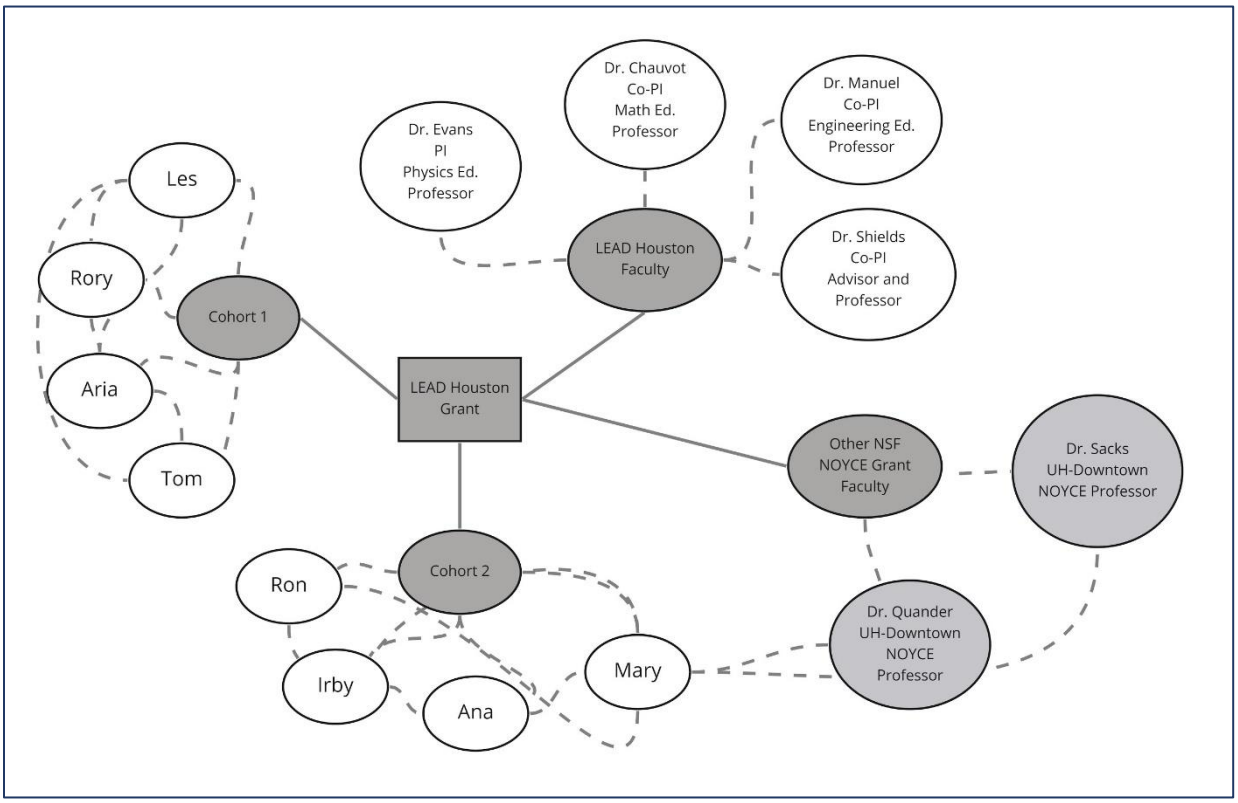


Figure 17. NOYCE grant faculty impacting the cohorts

The focus group members then spoke about "the cohort component/the cohort model," and how it is "so unique and powerful in a way where people from different backgrounds and different schools come together and with different personalities and different foci while at the same time finding common ground where [they] all grow."

Rory mentioned that he could have entered educational administration, but the **LEAD Houston** possibility with ***teach*HOUSTON** opened up at the same time and thrilled him. He is grateful for the opportunity afforded him. **LEAD Houston** (***teach*HOUSTON**), Rory reflected, "has truly been a blessing to [him]." (Figure 18)

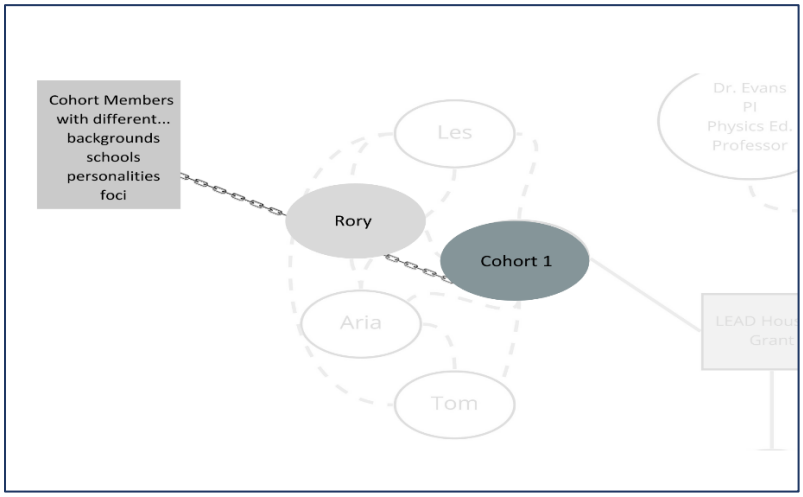


Figure 18. Rory's perceived value of the cohort model

Aria chimed in: "It has been wonderful—a tremendous experience." She continued:

> I cannot say enough about it about how much it has benefited my knowledge of education and me. Also, just interacting with people who are like-minded (science-minded?) and bouncing ideas off each other…especially with people who have such different backgrounds. I echo the kinds of things that Rory, Mary, Les and Tom have said.

Ana added: The cohort piece has been phenomenal. I feel like this program has been transformational for me personally, in that I have been able to grow, surrounded by people

that I am comfortable with, but who have different viewpoints and different perspectives than me. The differences have allowed me to grow in a wonderful way, and I, in turn, have been able to improve or work toward change in avenues that I never would have felt comfortable doing before.

Ron reinforced: What I have especially liked have been the strategies of how to build discussions of culture into classroom interactions… I would not have understood how to incorporate culture if we were just reading about it…However, seeing it in action drives points home for me… the field-based experiences and conversations do that for me.

Aria continued: It just consumes my interest. That is what I told my spouse. It has been very transformational not only as an educator, but as a person. Like Ron said, the cohort is a powerful idea. I think the **LEAD Houston** faculty do a great job of selecting members of the cohort. It was a competitive process.

"We all gel…we all mesh…I learn so much from the conversations we have. Our conversations are so powerful," Irby added.

Les then spoke from his perspective, which was quite different from the others:

For me, it is a change. I became a teacher via the alternative certification route. I did not have a lot of the starting out things that other teachers have. Of course, I had a year's professional development. However, **LEAD Houston** is different from that kind of preparation. I never complain about it. I actually enjoy the learning; I really learn from the discussions. The other thing is that I go to work and work all day. After that, I go to class and I really like what I am learning. In the past, I complained, but I do not complain any more. It is actually like a good party. I have surprised myself—really surprised myself (Figure 19).

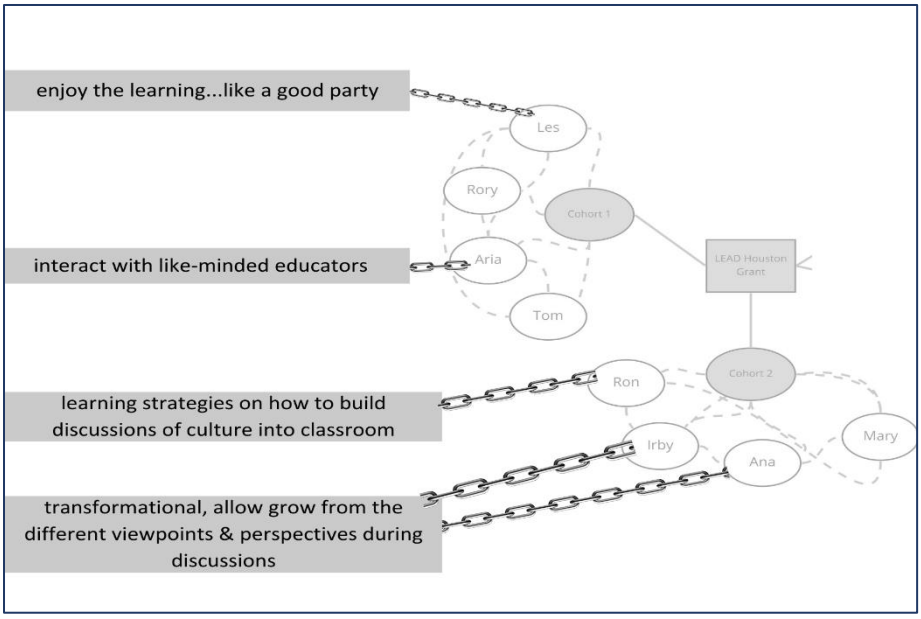


Figure 19. Value of the Cohort Model

Mentors, Mentees and Mentoring

Tom mentioned that he had many questions throughout the **LEAD Houston** program, especially where "culturally responsive teaching" was concerned and how to integrate it into the classroom. He said he took many questions to Dr. McAlister-Shields. I "bugged her a lot. She was always very helpful. I never was afraid to ask her anything. She mentored me a great deal…" Les added: "Yes, she would just chime in and add to discussions in the most remarkable ways…"

Aria: I liked the environment that Dr. Chauvot set up for the discussion of sensitive topics. She made the classroom feel like it was a safe place to have those sorts of discussions…

Ron: With her, we could discuss those touchy topics. However, at the end of the class, it was as if nothing happened.

Ana: I always liked the frankness of Dr. McAlister-Shields…There was no topic that was too sensitive to discuss.

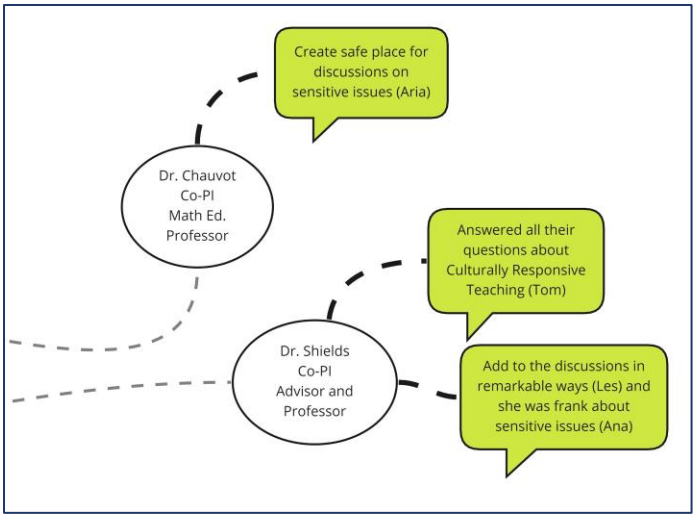


Figure 20. Mentors influence on the flow of conversation within the knowledge community

Irby: Agreed. And if we needed help and mentoring with engineering? Then Dr. Manuel would be my go-to person. I would also consult her about STEM or STEM applications in the classroom.

Rory: I concur. Dr. Manuel can help all of us see how things look in practice.

Aria: I think all of us would go to any of the Faculty about the theory-practice relationship. The whole **LEAD Houston** program kept a very good balance between the theory and practice, the readings and what we were exposed to, but then at the same time the hands-on experiences.

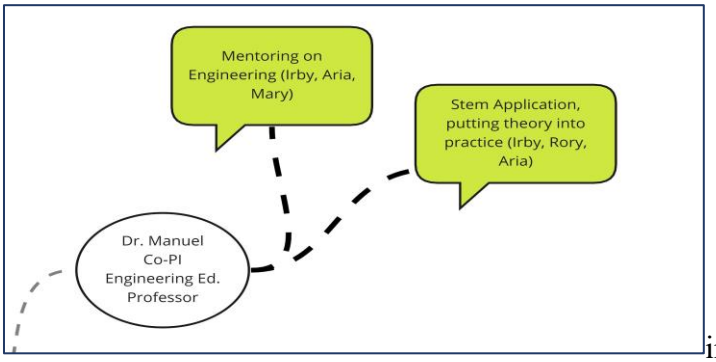
Ana: I agree that every professor had almost a superpower when it came to helping and mentoring us through the program…Dr. Chauvot got it started with an eye-opening course to begin with and then everyone else fell into place and took up their roles in supporting and shaping us…

Rory: Dr. McAlister-Shields facilitated a growth in me as far as equity goes. I am so thankful for that.

Aria: And Dr. Manuel helped foster my inner engineer. She had no clue of how frightened I was to sign up for her engineering course. And, by the end of it, I was telling my spouse. “It

was broken. We fixed it. It was a complete transformation for me...”

Mary: I had that kind of transformation too. I was one of those people missing the E (Engineering)



in STEM…And I am not lying…Dr. Manuel helped me all along the way…

Figure 21. Dr. Manuel and the E in STEM

Tom: I have never ever questioned whether a professor was available to talk to me to answer questions even now that I have graduated with my degree. I feel very comfortable reaching out to all of them, especially Dr. Evans. She is our advocate when it comes for making sure that the program is running efficiently and that we are getting what we need.

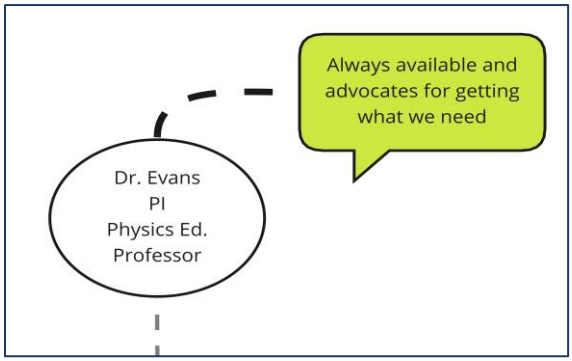


Figure 22. Mentors as advocates

Mary: Every single professor is ready and available to help in whatever way we need to be mentored. I know that is a strong endorsement. But that is the truth…

Rory: I am grateful for Dr. Leah McAlister-Shields because she saw something in me and

encouraged me to keep applying for the program…

Aria: And Dr. Evans is my hero. She wanted me to be a part of this cohort although I was personally lacking in confidence. She has worked at building me up ever since (Figure 23).

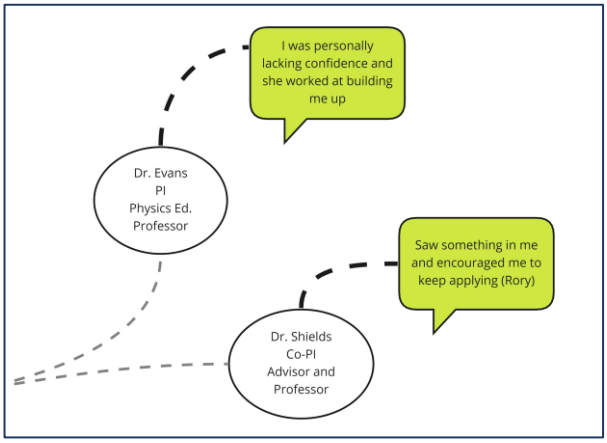


Figure 23. Mentors instill confidence

Les: For me, each faculty member has individual strengths. They are all very enthusiastic about what they are teaching, and they make you enthusiastic about it, too. I learned a little bit from each. From Jacqueline Ekeoba (Professional Developer with **LEAD Houston** and ***teach*HOUSTON** faculty member) I learned about natural science, from Mariam Manual I learned to do engineering reports, from Paige Evans, I learned how to better do inquiry science labs and from Leah McAlister-Shields, Mariam Manuel and others, I learned how to think about ethics and equity and culture responsive teaching so every class was balanced despite it being different every time.

Ana: Yes, they all brought you into the topic—invited you into it—and made you feel comfortable. They made you feel it was safe enough to ask questions or make comments. In addition, they were willing to share their experiences in the classrooms…. We just go to different faculty—for different things… I find myself modeling some of the things they do with my students…Also, the way they are organized and how they communicate…

Aria: We all came in as strangers, but we will leave as STEM professionals and personal and professional friends. We no longer are strangers… Our professors support us,d our peers in the classroom, at the university, and at home. They are not afraid of engaging us in uncomfortable conversations.

Ron: It has truly taught me a lot. All of it makes me a better leader.

Irby: As I have said, it has strengthened my leadership capacity. I have organized a very big professional development session, something that I would never have done…

Aria: And it is not really the big things… It is the examples they set as they lead the way and how they treat people. We watch and model the little things we are doing…. (Figure 24)

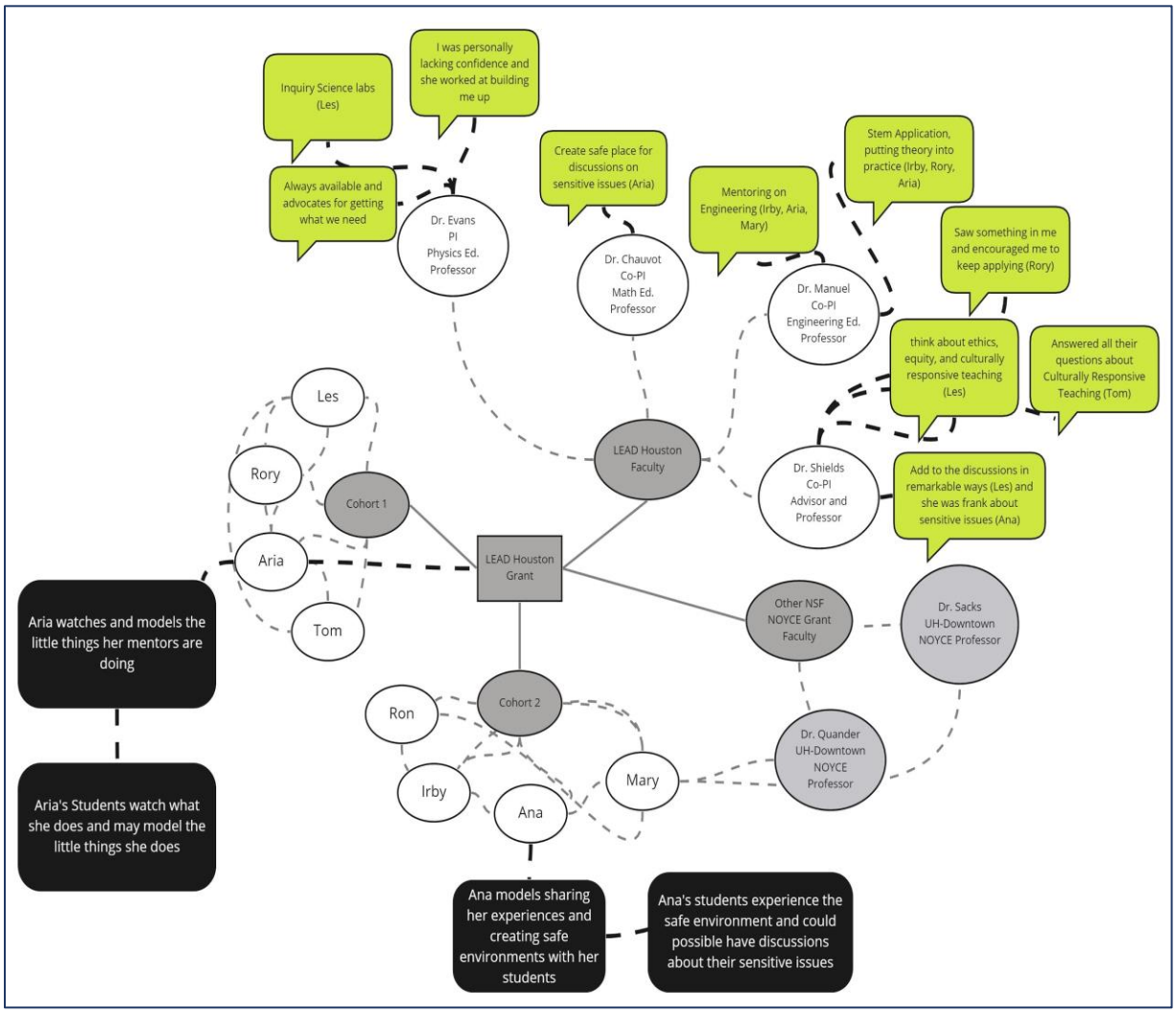


Figure 24. Ripple effect of chain mentoring

Towards provisionally conceptualizing chain mentoring

UH-LIFE

As introduced, mentoring in the UH-LIFE grant program began with Paige Evans and Donna Stokes, the PIs of the original Noyce award. However, as the UH-LIFE program took flight and matured, other faculty members' paths intersected with the students who themselves were organized in cohorts that also formed knowledge communities where knowledge constantly flowed in and rippled out. UH-LIFE students consistently identified with their cohorts *and* with members of their cohorts. Once these knowledge communities were created, the students were able to name a broad range of faculty, fellow students and teachers in the field with whom they established communities of knowing. This provided ample evidence for us to capture the chain mentoring that emerged.

Carmen was the first in the UH-LIFE grant to divulge that she took advantage of "every opportunity to network." Belonging to this networked cohort were ***teach*HOUSTON** faculty, other preservice and in-service teachers, and Grade 6-9 students locally, nationally and internationally who had registered for the virtual tHSI camp and its courses. Carmen and her colleagues most especially connected with Mariam Manuel who assisted them with their teaching online. Still other students like Martin were connected with Mariam Manuel, the Master Teacher of the Engineering Design and Innovation Group, and Ramona Mateer, the Master Teacher of the Earth and Environmental Science Group. He also had previous ties with Jacqueline Ekeoba who had a strong mathematics background. Then, there was Jake who was attracted to Ekeoba's creative pedagogy and appreciated Laura Harlow who was instrumental in helping him establish a strong career path. As each member of the mentoring chain suggested, knowledge communities had to develop or

previously exist for mentoring to happen. Knowledge was exchanged at each point of contact and flowed to and through key individuals (Master Teachers in particular). As we humorously learned in the discussion, some students even had their E (Engineering) in STEM "fixed"—after admitting that it was "broken."

LEAD Houston

Evidence of chain mentoring also appeared as an identifiable phenomenon in Exemplar 2. Mary, for instance, graduated with her bachelor's degree from the University of Houston, Downtown, which also was awarded an NSF Noyce Grant. She referred to two UH-Downtown STEM professors as her mentors: 1) Jackie Sack (mathematics teacher educator) and 2) Judith Quander (mathematics professor). At the University of Houston, Main Campus, she named a third mentor, Jennifer Chauvot. These faculty members are important parts of Mary's mentoring constellation.

Other mentoring chains presented themselves as well. They particularly emerged when **LEAD Houston** graduates clustered on one campus. For example, Ana considered some of her mentors to be her peers, alongside two ***teach*HOUSTON** and **LEAD Houston** faculty members (Paige Evans, Mariam Manuel). However, she also is mentored by a **LEAD Houston** graduate, Alicia, on her campus, Alicia is a mathematics major while Ana is a science major (Figure 2, p. 4). Despite content area differences, they have many commonplaces of experience (Lane, 1988) with the **LEAD Houston** program and the Noyce Master Teacher Fellowship being two of the most prominent.

At still another Houston area high school, one assistant principal is a ***teach*HOUSTON** graduate and the Science Department Chair is a **LEAD Houston** Fellow. Within the Science Department are two more ***teach*HOUSTON** graduates who were hired in different academic years.

This group mentors preservice teachers involved in summer camps and Noyce Scholars. They have invited several ***teach*HOUSTON** preservice candidates to do their practicums at their school. At the same time, they are identifying likely new hires for 2021-2022. This is a further example of chain mentoring, which the section below is as well.

LEAD Houston Noyce Scholars' targeted leadership and impact on Houston area schools

Rory: So, this year has been crazy with everything going on. I feel like it has exposed serious inequities in so many different areas and in education, and it is more than I thought. It is a little heartbreaking but one thing that I am doing is, as a member of a team of people at our campus, I help to plan certain things. I have taken charge of that group—policies and procedures, you know, and things like that.

Annie: I am learning that there are lots of things that a district needs to know about that does not happen at a campus level…The communication from a campus to the districts is disconnected where leadership is concerned. That is what I am working on—how I communicate in an effective way to tell the people who have some sort of power— or at least who I perceived have power.

Mary: Yes, how do we communicate needs on a district level so we can advocate for students and explain that our students suffer from poor policies or for poor procedures put in place. That is why I cannot wait to dive in more to the policy part of the program, which I think will come in the final year. The same questions keep popping up when teachers come into my room, shut the door and ask, who are we going to tell about what is happening? They ask: "Who is going to help us?" I do not have an answer and I want an answer. In addition, what can I take charge of myself? I have been taking notes and figuring out whom I need to contact at the district level. I want to hear different people's perspectives—multiple

perspectives—feedback, I guess and internalize it as I seek solutions…

Ron: On my campus, I have become more vocal…more take-the-reins instead of noticing that something is not right and trying to find the person that can fix it. I have started becoming the person that is going to figure out a way to fix it.

Irby: We applied to be a National School of Character; we won at the national and state levels. It is all about character in the schools and how everything is going to unfold. I am one of the ones in the meeting who is talking about equity and making sure all student voices are heard. If we are talking about the character of this school, I am trying to make sure there is no student marginalization in the process. I was lucky this year that one of the teams that I am working with is the physics team. It is concerned about equity—especially where testing is concerned.

Les: We are working on the students moving into the advanced sciences. We are trying to figure out ways to improve the number of minority students in the advanced sciences and the number of female students that go into hard sciences and pursue advanced sciences in college. We are spending a lot of time looking at the data. We are first looking at the number of African American students who are going from biology into the advanced sciences. Our number of Hispanic students is low… My school is 30% Hispanic and only 4%, or less than 4% do advanced sciences. We are trying to figure out ways to encourage them to keep going with the sciences and figure out why they are not in the advanced sciences.

Rory: Also, what students are being encouraged to do after they are in their freshman year in college… In my high school, we are looking at things as the construction of test questions. That is part of my/our take-charge approach.

Aria: Yes getting into good trouble—I have spoken about this before…In my case I hold two

roles that I would say that are beyond regular teachers. One is teacher leadership, which is a teacher development program for the district. The other is focusing on data and assessments…and how we assess, the validity of the data we are looking at and how to use data-driven student instruction amid so many variables.

Tom: As I discussed in our interview, I am focused on connecting preservice education, in-service education, and leadership… I am enjoying being a cooperating teacher for ***teach*HOUSTON**. I have mentors in ***teach*HOUSTON** and now I am mentoring student teachers as they take a peek in my classroom, which by no means is the best example or perfect or anything like that at all. On the contrary, I just see it as part of my growth journey, having witnesses of learning along the way. I give them a glimpse into practice while I am being mindful of practice and what I am doing and what I have neglected in instruction. It is an extra responsibility, which comes with taking on leadership. I would not give it up for anything in the world. I would keep encouraging these preservice teachers to come in and make observations. We all share the teaching and are part of the classroom. It is a way for them to get past me as the teacher of record as I always tell them. More than that, we share that we share the teaching so you (as an observer) are part of this classroom. It is about embracing the community of teachers and taking up possibilities. I feel passionate about it and I serve the community.

Ana: I think leadership is about planting seeds. We do not see the students that our student teachers teach. Most likely, I will never see any of those students. It is very rewarding to be able to look beyond the school you are serving. This is the touching eternity theme. Many times, you are working with your department or administrators and inevitably, a sense of frustration sets it. I do not think things are going to change. Then you catch a glimpse of

the possibilities of what is out there. It keeps you going. It keeps reinforcing the fact there is a learning community beyond the school where you work.

Irby: We need to share the stories—our own stories, too—of why we decided to become a teacher. Students identify with stories. They are so much richer than "I went to high school. I decided to study this and decided to become a teacher." We need to know how the seeds of becoming a teacher are planted. Our roles as leaders touches upon this as well. How did the seeds of leadership become planted in us? (Figure 25)

Mary: I see people that have the potential to be a leader. Sometimes my students come to me and say that they want to be teachers…I think it is those kind of moments that I cherish as a leader (Figure 25).

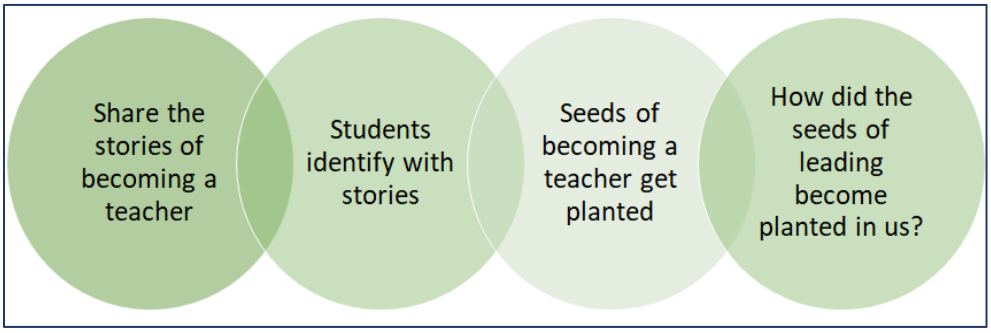


Figure 25. Planting seeds of teaching and leading

Student Reflections on Interviews and Focus Group Participation

In addition to centering on their connections and moments of success, the focus group reflected backward on participating in the interviews and focus groups and found a way to couple their work with those of us who conducted the evaluation process.

Tom: Great job of facilitating…I got everything out in the interviews and focus groups and have nothing more to add…

Rory: Everything I wanted to talk about today was said.

Amy: I feel closer to my peers today because of this conversation.

Irby: I think we grew the network through this talk.

Ana: I can approach my fellow Noyce Scholars and ask them about how they managed to do this or that. I know more about what each of us is doing.

Les: You specifically asked what we are learning…Nobody specifically asks us that question.

Aria: *We were learning about teaching while we were talking about teaching. We were learning about leading as you are modeling leadership* (Figure 26).

Figure 26. Chain mentoring themes

What we term chain mentoring is a major outcome of the **LEAD Houston** and the UH-LIFE Grants. The knowledge communities formed within and across mentors/mentees are a second major outcome. The third major contribution is the knowledge generated by these chained communities of knowing, which enriches understanding of the nature of inquiry, the value of feedback and the importance of approaching teaching in culturally responsive ways.

Themes

Influence of the Pandemic

What the pandemic did in 2020-2021 was to intensify everything in the high stakes STEM learning environment that already was high-pitched by its very nature. The students in the cohorts needed to work to retain their scholarships but the NSF conditions that would ensure their scholarship continuation had radically changed in a blink of an eye. In short, the pandemic forced everyone to adapt whether individuals wanted to or not. Some used the Covid-19 debacle to improve shortcomings in their practices (e.g., putting the E back in STEM). Others attempted endeavors (e.g., organized a large online professional development event) that would have been

unfathomable before. What the global pandemic brought to the fore was the outstanding need to attend to the socio-emotional needs of students and faculty and how those needs might be dealt with in the constrained online environment that was their "new normal." This especially was evident when the ***teach*HOUSTON** students became vulnerable with one another in class and shared narratives of bullying, gender bias, stereotyping, and racial profiling, many of which they had personally experienced. They additionally shared the pain of not becoming the doctors that their parents had desired for their preferred futures.

Influence on Knowledge Communities

In this work, knowledge communities took on heightened roles than previously was the case. Without the intentional and unintentional cultivation of knowledge communities, there would not be as many high quality interactions taking place between and among *teach*HOUSTON faculty and *teach*HOUSTON students, *teach*HOUSTON students and other *teach*HOUSTON students, and *teach*HOUSTON students and the grade school students they taught. To cut to the quick, mentoring would not be as rigorous and as varied as it was--even in the forced online teaching environment. There is no doubt that mentoring has a vital knowledge component (e.g., disciplinary knowledge) to it as this STEM content study makes clear. However, this work also unavoidably deals in relationships and emotions. This is especially true for "students of color in higher education who face myriad challenges that supersede the academic, including feelings of isolation, lack of belongingness, and overt discrimination that confers stress on top of their academic workload" (Chin & Kameoka, 2019). A comprehensive review of empirical studies on campus climate by Hurtado and colleagues (2012) showed overwhelming evidence that minority students...tend to deal with a more hostile environment than other students. Consequently, those students "often feel more disconnected from their institutions and tend to report lower scores on

critical affective (e.g., self-efficacy) and cognitive outcomes (e.g., grades, degree completion) (iCount, 2013). Hence, the need for mentoring and for cultivating knowledge communities was at an all-time high during the pandemic. At the same time, picture frame photos on computer screens prohibited students' whole-beings from shining through. The cohort model specifically helped in this regard with knowledge communities developed between and among peers filling in gaps and virtual "dead spaces" that were wooden and difficult--if not, impossible, to overcome.

Development of STEM Teacher Identity

An integral component of the teachHOUSTON Master Teachers' role involved cultivating confident, efficacious future teachers who feel empowered to make a difference in the lives of their students. The formation of teacher identity in the STEM disciplines starts with early field-based experiences that require preservice teachers to conduct observations and teach two lessons in secondary STEM Houston-area classrooms. These visits are significant because through them the master teachers discuss not only pedagogically promising practices, but also teacher professionalism. The latter includes attire, email etiquette, and using title prefixes along with the last name, example: Mr. /Ms. Rodríguez or Instructor Rodríguez. Once the preservice teachers step in front of a classroom they are prepared to command the attention of their students through using common classroom management skills such as cold-calling, attention getting, and the use of voice projection often referred to as the "teacher voice." Hence, the field-based courses are designed to provide preservice teachers with rich and fulfilling experiences that provide insight into classroom teaching and are empowering in ways, which contribute towards their perception of themselves as teachers.

Other equally important facets of the program that influence teacher identity include discussions and activities that explore their beliefs about teaching and learning. These activities

are strategically guided through dialogic interactions with their peers and master teachers that help challenge preservice teachers' conflicting conceptions and promote meaningful discourse in the classroom. Throughout the programmatic coursework, preservice teachers are provided with opportunities that yield critical self-reflection coupled with feedback from master teachers and classroom teachers with whom they are completing their field experiences. Moreover, the research-driven teaching strategies, both modeled and discussed, are fundamental in the shaping of preservice teachers' teaching philosophy statements, which are developed throughout the program and are sharpened during the final student-teaching semester.

The **LEAD Houston** Master Teacher Fellows (MTFs) have embarked on their individual and collective journeys with an eye to developing their identities as STEM Teacher-Leaders. MTFs have led sessions at the NSF Noyce conferences and National UTeach STEM Educators' Conferences. Moreover, many MTFs are providing professional development to their colleagues through school and district led initiatives, as well as during Professional Learning Communities (PLCs) in their content area teams and departments. Other ways in which MTFs are demonstrating their leadership and agency to cultivate change includes writing curriculum, authoring new courses, initiating teacher and staff seminars on topics of equity and inclusion, and meeting with school/district administrative leaders to discuss the critical need for teaching through inquiry-driven and culturally responsive methods.

Knowledge and Enactment of Culturally Responsive Pedagogy

Enacting Culturally Responsive Pedagogy (CRP) was a challenge expressed by preservice teachers and university faculty throughout the pandemic experience. As the successful utilization of CRP relies heavily on relationship building, teachers and students alike had to create meaningful connections via online platforms. Although convenient and safe during the pandemic, such

platforms can limit the types of activities and teaching strategies teachers use to build rapport with students. For example, greeting students with the use of handshakes unique to each student, or tasking students with classroom responsibilities such as cleaning the whiteboard, to build confidence and leadership, were unavailable CRP classroom management strategies that while effective in-person, were not an option to teachers, educating in an online setting. Limitations in the use of online settings became a breeding ground for creative approaches to the enactment of CRP and relationship building. Examples of this include the aforementioned handshake greetings, ability to make eye contact during conversations, and the comfort of connecting on a human level that is often contingent upon physical proximity. Additional challenges teachers faced were the already limited access to examples of CRP being used in face-to-face learning spaces, and a near absence of examples in the use of CRP in online settings. Such challenges only necessitated the creation of CRP approaches that were easy to enact in online settings, and it also encouraged teachers to share what they were doing in intentional ways and record with other teachers their use of CRP focused teaching strategies and resources. Specifically, preservice teachers and in-service **LEAD Houston** Master Teacher Fellows (MTFs) struggled with finding model lessons that incorporated STEM content and were responsive to cultural and linguistic diversity of students being taught. Hence, through the production of innovative curricular resources, MTFs are trailblazers, not only for their schools and districts but also for future STEM teachers at ***teach*HOUSTON**.

Furthermore, the summer 2020 incidents of racial injustice in combination with the digital divide resulting from the ongoing pandemic, magnified the challenges existing in our K-12 education system that severely impact the most vulnerable populations in our country: students of color, students with disabilities, and students from low-income households. Hence, the **LEAD**

Houston team reflected on the significance of the moment and the work needed to incorporate culturally responsive instructional practices in STEM classrooms of MTFs even in remote settings. Accordingly, the **LEAD Houston** Professional Development Co-Directors, Drs. Shields and Manuel, along with feedback and guidance of Drs. Evans and Chauvot, produced seminars on building students' funds of knowledge during online learning, and shared activities on diversity, equity and inclusion modified to fit the remote instructional setting. The faculty and MTFs took time to discuss the specific needs each fellow had at their schools and districts along with barriers and catalysts they have experienced in route to incorporation of CRP. These conversations allowed **LEAD Houston** faculty to design sessions that are responsive to needs of the MTFs. For example, a current area of need that has emerged is battle fatigue experienced by MTFs who have been advocating for equity and inclusivity at their schools while also balancing remote and in-person (hybrid) instruction as the pandemic continues to take its toll on educators. Currently, the **LEAD Houston** faculty team is working on launching a book study that will be paired with professional development seminars that have been designed to alleviate the pressure while synchronously building the MTFs' capacity around tenet three of CRP; that is, sociopolitical consciousness (Ladson-Billings, 1994, 2009)

Chain Mentoring in Multiple Communities of Knowing

To this point in this paper, we have provisionally proposed that chain mentoring became animated in multiple knowledge communities, with some instances happening by design and others occurring by happenstance. We also shared in detail how our concept of chain mentoring resonated with our two previous conceptualizations: 1) multi-layered mentoring (which considers hierarchical relationships), and 2) generative mentoring (which juts out in all directions). This makes all three conceptions compatible, as we sought to more closely study the phenomena.

Our featured exemplars, which are filled to the brim with instantiations of chain mentoring, illustrate in fine-grained detail queries and interactions that took place between particular people. We intentionally ended our exemplary cases with complex anchor figures capturing the sum of the parts to illuminate the complexities of human relationships and interactions.

Most of all, readers witness in this paper how the students' knowledge communities participation awakened them to the strengths of those around them and how they used that--even in an unidimensional online learning environment--to lean in on different peer and faculty mentors to address different felt needs. This leaning into others bridged all the disciplines in STEM and allowed students to learn across the content areas, especially since important lessons like CRP traversed the chains in which their relationships were situated and affected their interactions. These exchanges involved faculty, peers and ultimately the students they teach in less-than-ideal circumstances and not-at-all what the students signed up for in their contractual agreements.

From a theoretical perspective, a prime example of social networking theory (Christakis & Fowler, 2009; Fowler & Christakis, 2010) had life breathed into it in this narrative inquiry investigation. Social networking has to do with three degrees of separation and ultimately the reach of influence from one individual to another (or set of individuals to another set of individuals) [e.g., cohort to cohort]). According to the theory, what one individual says and does influences other individuals' thoughts and behaviors (first degree), who, in turn, affect other individuals' thoughts and behaviors (second degree), with other associates of individuals affecting yet another band of individuals (third degree). This means "(i) behavior[s] (CRP? inquiry teaching? mentoring approaches?) can spread from person to person to person via a diverse set of mechanisms, subject to certain constraints (global pandemic?), and (ii) as a result, each person in a network can influence dozens or even hundreds of others, some of whom he or she does not know and has not

yet met" (Fowler & Christakis, 2009, p. 5337). This exemplifies what has transpired in ***teach*HOUSTON** with ***teach*HOUSTON** alumni—not initially known face-to-face by students—exerting their influence in ways that cascade throughout the innovative STEM teacher education program, constantly taking classroom and field-based learning up a notch and adding to the complexities to the delivery of ***teach*HOUSTON** and to what is available to be studied in the future.

Concluding Thoughts

In the final breaths of this pandemic chapter of ***teach*HOUSTON**, we address begging questions that arose along the way as we engaged in this provocative research during the pandemic year.

What will *teach*HOUSTON consider in the heels of **the pandemic?**

At the onset of the pandemic and the subsequent switch to online teaching and mentoring, it initially did not seem possible that so many positive elements would be retained of the ***teach*HOUSTON** program. At the time, we were in survival mode and were doing our best to take care of fellow colleagues, preservice students and in-service teachers. As we earlier noted, we privileged socio-emotional learning in a way we had never done before. Moreover, we were struggling to learn how to teach on an online platform while staying true to the ***teach*HOUSTON** philosophy, which is grounded in inquiry-based learning, culturally responsive pedagogy, and an overall student-centered approach. However, we adapted to online teaching and mentoring and we took it a step further by creating the ***teach*HOUSTON** STEM interactive that broadened participation in STEM in unprecedented ways. Thus, there are many positive outcomes with this unexpected experience that will be retained as we return to the "new normal."

What will be retained? Having experienced the pandemic, we are convinced that learning

to teach online is a necessary skill for future teachers to embrace, as we do not know what the future holds in terms of environmental and medical issues. Thus, we will prepare future teachers to teach both face-to-face and virtually via lessons and field-based experiences involving both modalities of instruction. This provides more flexibility in teaching during the hurricane season and anything else (e.g., floods, snowstorms, plagues) that happens our way. Additionally, we plan to continue the ***teach*HOUSTON** STEM Interactive. Readers will recall that our typical summer STEM camp served approximately 60 students and that our virtual endeavor impacted approximately 3,000 students globally. Thus, all who were involved in this endeavor, additionally, faculty and preservice/in-service teachers plan to continue the ***teach*HOUSTON** STEM Interactive. Hence, we are currently seeking funding for future years. Faculty also noticed that there is an opportunity to enhance mentoring by combining both in-person and online meetings. They realized they had more opportunities to meet with preservice teachers in office hours and advising sessions if neither faculty nor students had to deal with city traffic.

What will return to normal? Interpersonal relationships will return to face-to-face, the. ***teach*HOUSTON** office will be open and continue to be a one-stop place for students to get their questions answered. The connections with ***teach*HOUSTON** alumni teacher**s** will also resume once their workloads in the schools are more manageable and less stressful.

What will be the 'new normal'? *teach*HOUSTON has learned that the use of technology expands its local, national and international reach as a leading national and international secondary STEM teacher education program. Ironically, the tHSI summer activities will stay online. However, face-to-face meetings, email messages, and Facebook exchanges will supplement its mentoring sessions.

What grants lie ahead? As far as the future of ***teach*HOUSTON** is concerned, we plan to continue

to grow the program and to improve upon our model by incorporating policy and advocacy in the **LEAD Houston** grant, sharing our innovations on a national platform, expanding our professional development with in-service teachers, and obtaining new grants. Funding provides not only support for future innovative initiatives grounded in racial and social justice, culturally responsive teaching approaches, equity, and inquiry-based teaching strategies, but the support will help to provide access to these initiatives where preservice and in-service teachers from underserved populations typically may not have opportunities. Of these opportunities are a 14-month master's degree in STEM Leadership with tuition was provided for all scholars (i.e., Master Teacher Fellows) in addition to a $10,000/year stipend for the four years following the completion of their master's degree. Such an initiative provided scholars from underserved populations the ability to acquire a master's degree fully funded as well as receive additional funds to remain in the classroom sharing their newfound knowledge often with students from very similar backgrounds as themselves. Providing MTFs with the ability to receive a graduate degree, tuition provided, addressed the issue of educational access so often experienced by students of color and from low-income households. Funding helped to support in-service teachers from racial, cultural, and linguistically diverse backgrounds pursuing graduate education while reducing the financial gaps and hardships often faced when deciding the economic feasibility and impact such a decision will have on their future lives.

How can *teach*HOUSTON break ground in STEM education policy and advocacy? As the **LEAD Houston** Master Teacher Fellows (MTFs) progress in their integration of CRP while developing their own sociocultural political identity (Ladson-Billings, 1994), the next step in their journeys is to embark on policy advocacy at the local, state, and even national level. Equipped with expertise in areas of STEM education along with a heightened awareness of CRP and social

justice issues in education, MTFs have started sharing their newly acquired skills and extending their impact beyond the walls of their own classrooms. Change agents have been described as individuals who "intentionally make things happen by [their] actions" (Bandura, 2001 https://www.annualreviews.org/doi/full/10.1146/annurev.psych.52.1.1). Additional research states teachers serving as 'change agents' have well developed pedagogical content knowledge coupled with a sense of responsibility to solve problems in their schools (Lukacs & Galluzzo, 2014). According to Schwab, the originator of science as inquiry instruction, teachers are not merely agents of subject matter, they are "agents of education" in its entirety (Schwab 1954/1978, p. 128). Thus, as MTFs progress through **LEAD Houston**, they are charged with serving their classrooms, schools, and communities as agents of social and educational change, actively championing for inclusivity and cutting-edge approaches to teaching STEM.

In the coming years, MTFs will receive professional development to explore current regional and national STEM education policies. MTFs will identify areas of need in an effort to serve as agents of change advocating for reform at the school, district or regional level through a variety of possible pathways of their choice. Examples include enacting innovative grading practices and classroom management approaches, as well as transforming existing curricula from traditional to an inquiry driven method. Moreover, PI Paige Evans and Co-PI Mariam Manuel have regularly attended the American Association of College for Teacher Education (AACTE) Day on the Hill, an annual event preparing and empowering university faculty members to meet with their senate and congressional leaders to discuss the impact and relevance of their teacher preparation program. Hence, the **LEAD Houston** faculty team will work collaboratively to organize state and national trips for MTFs to engage in advocacy with leaders in educational policy.

How can professional development for in-service teachers be increased? During the summer

of 2021, the program will conduct a professional development opportunity for 30 in-service secondary STEM teachers. This new grant initiative, University of Houston - Raising Equitable Access for Children in Houston (UH-REACH), will prepare 30 secondary teachers in Greater Houston high-need school districts to incorporate culturally responsive pedagogy (CRP) into their STEM lessons. Throughout the subsequent fall semester, ***teach*HOUSTON** faculty, and Master Teacher Fellows (MTFs) from the **LEAD Houston** grant will follow up with teachers via online Skype conferences to lend support as needed. Teachers will be provided with a $1000 stipend to attend the professional development and engage in online mentoring meetings with UH faculty and MTFs.

How can *teach*HOUSTON help shape the national landscape of STEM Education? As mentioned at the beginning, the ***teach*HOUSTON** program is the first replication site of UTeach, which now has been repeated in 45 sites nationally. Therefore, there are opportunities to share our innovations in coursework. More specifically, amongst this network we have become one of the premier secondary STEM teacher preparation institutions embedding culturally responsive pedagogy throughout our educator preparation program (EPP). Additionally, we have received national recognition from federal funding agencies such as the National Science Foundation, and the Department of Education and at prestigious educational conferences such as the American Educational Research Association regarding the enactment of CRP. To further advance CRP, we recently designed and incorporated a classroom management course where students analyze the overall learning environment including the value of lesson planning, classroom structures, and culturally responsive pedagogy as pertaining to classroom management.

What about recent and future grants? Thus far, we have been successful in obtaining several federal grants that support our vision and growth such as the NSF Noyce grants, UH-LIFE and

LEAD Houston, which have both been pivotal. Recently, we were awarded an additional Noyce grant, Preparing STEM Teachers through Advancing Cultural and Computational Engagement in STEM Scholars (UH-ACCESS). Just underway, this grant is creating a pipeline for preparing secondary STEM teachers trained in high-need fields through a partnership with the College of Technology and the Departments of Computer Science and Physics. It offers an inquiry-based computer science education course and a Teacher Interest Group, which will help students build community and offer support, and provide opportunities to participate in community events incorporating a culturally responsive context in addition to our ongoing embedded mentorship approach. Future grants will support the enhancement of an expedited pathway for career changers, which started in 2019. This pathway allows for seniors (with one or two classes left), recent graduates, or career changers to receive teacher certification in 9 months. In order for this to be accessible to all, it is important to have funds to support future teachers as they participate in this rigorous teacher certification program. Additionally, we applied for three NSF grants, one that would result in the creation of a new course on Engineering Design and Technology Education, another that would enhance the computer science and engineering strand in the program, and a third grant proposal that will provide preservice teachers with the opportunity to complete summer coursework and receive professional development on mentoring students from underrepresented minority populations and employing culturally responsive pedagogy.

What is the future of *teach*HOUSTON?

This body of work contributes to the preparation of preservice STEM teachers by specifically highlighting the chain mentoring that transpired during the pandemic. Faculty and both pre and in-service teachers learned to create a supportive environment inclusive of mentoring and inquiry, mentoring and feedback, and mentoring and culturally responsive pedagogy which we

deemed examples of generative mentoring in the *teach*HOUSTON STEM Interactive, funded by the NSF UH-LIFE grant (Evans, Craig & Manuel, in press). This was in part possible due to the multi-layered mentoring that was already in place prior to the pandemic (Craig, Evans, Stokes et al., under review). *teach*HOUSTON's dynamic approach to mentoring served as a springboard in the application of innovative new practices in the online setting which were grounded in the use of culturally responsive pedagogy and inquiry-based teaching. We hope that sharing the successes and struggles of mentoring during the global pandemic will not only illuminate promising practices embodying accessible and equitable opportunities for learning, but also the knowledge communities providing support and collegiality to make needed pandemic chapter changes in order to meaningfully engage *teach*HOUSTON students—and the secondary students who they teach—in rich, participatory educational experiences.

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