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STEM Teacher Educators' Professional Practices and Challenges: A Cross-National Comparison

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Abstract
Professional growth of STEM teacher educators remains an underdeveloped topic in educational research. In the current study, STEM teacher educators representing six countries: Argentina, Brazil, Chile, Colombia, Mexico, and USA completed a survey, which addressed teacher educators' professional trajectories, practices, and challenges they face to meet tenure requirements. This study utilized convergent mixed methods design applying survey research format and as such integrated both quantitative and qualitative data collection and analysis. Descriptive statistics and meaning coding of the survey and interviews allowed identification of emerging themes in professional practices. The main findings suggest that there are common trends as well as country specific professional practices across professional trajectories reported by participants. The study results reveal that the lack of support during the teacher-to-teacher educator transition period was a common feature across the countries. It was also evident among participants that their professional journey begins with an assumption that as teacher educators they should primarily excel in performing teaching tasks.

Key Words: Professional practices, STEM, teacher educators, international perspective

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Introduction

Through the unique lens of professional practice and professional trajectory we are examining and conceptualizing the constructs of practice and trajectory as linked to teacher educator roles. Teacher educators' professional practices and challenges are multifaceted. As documented in the literature, a critical period in teacher educators' (TE) careers is the beginning of the academic journey, which is characterized by a lack of induction programs (Murray, Czerniawski & Barber, 2013; Van Velzen, van der Klink, Swennen, & Yaffe, 2010). To grapple with this inconsistency, they attempt to gain the needed skills and tasks on the go after their appointment as teacher educators (MacPhail et al., 2018). In the absence of support during this transitional period, junior teacher educators resort to engaging in collaborative work with more experienced colleagues as a process of enculturating themselves into their new career (Hargreaves, 1994). The current study uses the concept of teacher educator as defined by Kelchtermans, Smith, and Vanderlinde's (2018) as "people who are professionally involved and responsible for initial and ongoing education of teachers" (p. 121).

Although standards for teacher educators exist in several developed nations (e.g., the United Kingdom, Switzerland, and the US), the preparation of future teacher educators seems to be the sole responsibility of individual teacher education faculties who provide informal apprenticeship opportunities to doctoral students and junior teacher educators. Koster and Dengerink (2001) argue that teacher educators should have content knowledge, pedagogical, organizational, group dynamic, developmental, and personal growth competencies. Others contend that knowing the content is not a sufficient condition for teaching, and that teacher educators should be knowledgeable about how students learn, curriculum, instructional strategies, and assessment to be able to facilitate their content knowledge (Abell, Rogers, Hanuscin, Lee, & Gagnon., 2009). Livingston (2014) maintains that, as an understudied group, the understanding of who is a teacher educator remains unclear, as well as an understanding of their professional practice and professional trajectory. From the diversity of opinions and assertions, the constructs of practice and trajectory are not well-defined and there is a research gap in clarity of how teacher educators' professional practices and trajectories are developed. An extensive volume of research in the teacher education literature has been focused on competencies that define teacher educators' expertise and their transition into academia, with little attention to the exploration of how teacher educators develop their expertise (Berry & Van Driel, 2013) and their professionalism (Kelchtermans et al.,, 2018).

At the international level, an assortment of studies have addressed the issue of teacher education professionalism. For instance, in The Netherlands the *Professional Standards of Teacher Educators* are implemented as a frame of reference of their practices (Dutch Association for Teacher Educators, 2011). In England, the Higher Education Academy participated in the creation of the 'Becoming a Teacher Educator:

Guidelines for Induction' (Boyd, Harris, & Murray, 2011). In other countries (Norway and Israel), colleges and departments of education, in conjunction with schools, offer induction programs and professional practice development programs to school-based teacher educators (Orland-Barak, 2005; Smith, 2015). Another important initiative was created in 2012 with the foundation of the *International Forum for Teacher Educator Development* (Info-TED) whose main goal is to bring together practitioners from across the globe to share their research and experiences related to teacher educators' professional practices. This organization seeks to raise awareness for the distinctive national and institutional contexts teacher educators work in and how they affect their practices as well as their opportunities to grow professionally (Vanassche, Rust, Conway, Smith, & Vanderlinde, 2015).

In terms of representative research of the Latin American approach to professional practices in teacher education, little is known about teacher educators in this region and their professional paths. The most relevant information comes from a study conducted by Montenegro (2016) with Chilean teacher educators. Chile is one of the countries represented in the study, the others being Argentina, Brazil, Colombia, Mexico, and the U.S. Overall, the study found that the professional path to academia in Chile is non-regulated. The choice to become a teacher educator is predominantly dependent on accepting an invitation to work in a teacher education program, which is more likely associated with the candidate's teaching abilities. This process seems to be more by 'accident' rather than by a pre-planned or personal decision (Berry & Van Driel, 2013). The process of employment, in general, features a heterogeneous group of teacher educators. Following the first years of teaching, teacher educators receive little or no support for teaching in a way that they mainly find themselves as solitary and autonomous learners in the process of becoming a teacher educator. In other words, it "is a path in which the individual experiences a rerouting along the journey" (Montenegro, 2016, p. 15). In this journey, pursuing a research agenda does not seem to be a priority, consequently the focus is primarily on teaching activities, which causes a weakness in their critical stance toward their professional practice. In the rest of the Latin American countries represented in this study, there is a scarcity of research on teacher educators' professional trajectories. Therefore, this area needs to be studied to not only enhance teacher preparation programs and educational policies, but to understand multiple perspectives, challenge the literature, and conceptualize the constructs of professional practice and professional trajectory.

The literature on how teacher educators develop professionally indicates that this line of research is still in its infancy (Lunenburg, Dengerink, & Korthagen, 2014), under researched (Livingston, 2014), and that there exist few studies addressing the teacher-to-teacher educator trajectory (Montenegro Maggio, 2016). The research of this topic is even scarcer in the Latin American teacher education higher education institutions. An inspection of the international teacher education literature on teacher

educators' professional paths and practices only reports the work of Montenegro Maggio (2016) with Chilean teacher educators. Likewise, but at the national level, Cornejo (2007) has researched the preparation of Chilean teacher educators which he identifies as a pending and major challenge for the Chilean education system. Similar studies have not appeared in the literature for the other Latin American countries.

Within an international comparison, the following question remains unanswered: what professional trajectories and practices are STEM teacher educators following to best prepare themselves for educating teachers in the 21st century? The proposed research is based on two main constructs: professional practice and professional trajectory. For the purposes of this study, professional practice is considered as self-directed learning that is informed by experience, research, collaboration, and knowledge. Professional trajectory is defined as the path within a personal learning framework that each teacher educator uses to integrate their interests, needs, passions and inspirations (Ontario College of Teachers, 2012). Concomitantly, we define professional practices using Kelchtermans, Smith and Vanderlinde's work (2018) as the "normative choices and judgment about what is an appropriate action in a particular situation enacted in the teacher educator's professional space" (p. 127). In addition to exercising their personal judgment, and while developing their individual practices teacher educators also enact their personal knowledge and beliefs, as well as their professional skills and attitudes. This complex set of knowledge takes place within a broader and multi-level context (e.g., local programs, national policy). Therefore, and as Kelchtermans et. al (2017) point out, it should not be expected to conceptualize professional practices and standards as linear and deterministic. In other words, each practitioner translates and negotiates policy prescriptions in response to their local resources and interests. This study identifies STEM teacher educator professional trajectories in Latin American countries, and in the South-western border region of the United States. The unique geographic location of our university (in the US) allows us to engage in collaborative work with other teacher educators in our neighbouring country (Mexico), and in some other Latin American nations. This cross-national study becomes a professional reflection exercise, which is important because within Transformative Learning Theory (TLT) (Ettling, 2012; Merrian, 2004; Mezirow, 2018; Taylor, 2017) educators need to identify and examine their own beliefs before attempting to change them (Moseley & Norris, 1999). In order to understand how STEM teacher educators develop their beliefs and competencies for teaching teachers, this study sought to answer the following research questions:

- To what extent do professional practices of STEM teacher educators vary across participating countries?
- What challenges do STEM teacher educators encounter in their professional practices?

Theoretical Underpinnings

It is important to acknowledge that teacher educators, particularly in the STEM disciplines, bring with them varying experiences, and for some, teacher education is a career they did not plan to enter (Berry & Van Driel, 2013). It is also important to highlight that they possess a dual level expertise, "teacher educators are teachers of teachers and their 'teaching subject' is teaching" (Kelchtermans, Smith, & Vanderlinde, 2018, p. 122). Currently, in many Latin American countries, legislation, public policy, and other socio-political factors seem to impact the work of STEM teacher educators' professional practices (as opposed to research-focused programs). This is evidenced in a lack of financial investment, which has repercussions on the quality of teacher education programs and on the opportunities for teacher educators to improve their professional growth. Teacher education resources are focused on maintenance, recovery, and sustainability of pedagogical knowledge as a necessity, rather than introduction of pedagogical innovations (Personal communication with Latin American colleagues, November 10, 2020).

Within an international context, we are seeking a better understanding of multiple indicators that present the trajectories of professional growth. "Naming and describing our frames of reference about education and our role within that world is part of our transformative journey as an educator" (Cranton, 2006, p. 193). For this study we chose the Transformative Learning Theory (TLT) (Mezirow, 2018) as the construct informing the design, implementation, and interpretation of the study. We explored the transformative learning journey experienced by a group of STEM teacher educators in enacting and carrying out the professional goals at their education institutions. In the context of this study, TLT allows us to elucidate STEM teacher educators' learning process that involves constructing and appropriating new and refined interpretations of the meaning of their new roles in the academia. In this sense, TLT lends itself as an appropriate theoretical framework because the process of learning develops with the use of prior experiences upon which individuals form new and revised practices that inform future actions (Taylor, 2017). The TLT, as a theoretical underpinning recognizes different reference points driving teacher educators' skills to identify opportunities, alternatives, and pathways that result in professional growth. "In transformative learning, one's values, beliefs, and assumptions become the lens through which personal experience is mediated and made sense of" (Merriam, 2004, p. 61). By using TLT, it is possible to identify teacher educators' responses (transformations) to paradigm shifts in their roles as teacher educators including social, economic, cultural, professional lives in academia (Erichsen, 2009; Kung, 2007; Ritz, 2006, 2010).

In addition to the TLT framework and theories of adult learning as underpinnings, relational teacher education approach (Kitchen, 2005) supports recognizing the uniqueness of each teacher educator's transformative experiences, including comparing and contrasting professional practices between countries, as well as content areas.

Understanding and improving on one's own personal practice by looking inward and backward (Kitchen, 2016) at experiences as a teacher educator (e.g., professional trajectory) facilitates situating oneself as a relational teacher educator.

Significance of the study

Studies addressing the professional growth of STEM teacher educators across nations, and over time, have several benefits: they reveal alternative approaches to professional practices, help identify subtleties of STEM teacher education that deserve analysis, stimulate discussions about needed improvements in the field, and they are informative of STEM education research orientations in each locality. We also believe that the exchange of expertise and resources through cross-national studies should be encouraged as a mechanism to improve the overall capacity of nations to refine and develop their research agendas in STEM education. Having a comprehensive perspective of teacher education of educators of STEM teachers across different countries allows us to know and understand the learning trajectories (Sztajn, Confrey, Wilson & Edgington, 2012) that have an influence on the preparation of teachers. The globalization of education and the challenges imposed by socioeconomic and political disparities affecting school communities in the 21st century establishes the relevance of this type of study. The professional growth of STEM teacher educators remains an underdeveloped area in education research in Latin America. A single study from a Chilean researcher is reported in the international science teacher education literature. Therefore, pursuing this study with a cohort of colleague teacher educators in Latin America will shed some light in understanding the professional growth of STEM teacher educators in this region.

Methodology

The methodology section includes the research design of the study, the description of its context, selection of participants, data collection, instrument, and data analysis.

Research design

This cross-national study focuses on exploring professional practices and trajectories of a group of STEM teacher educators with respect to their professional growth. The study utilizes convergent mixed methods design (Creswell & Plano Clark, 2018) applying survey research format and as such integrates both quantitative and qualitative data collection and analysis (Gay, Mills, & Airasian, 2009). Given the value that this study places on individual STEM teacher educator trajectories of professional growth, a survey research methodology is appropriate. As opposed to theoretical research, survey research allows for contributing to a body of conceptual knowledge of the discipline (Alreck & Settle, 2004).

As a cross-sectional approach to survey research, the primary data provided a

snapshot of professional practices and trajectories held by a geographically and culturally diverse group of STEM teacher educators. The adapted surveys were utilized as a springboard for data collection.

Participants and context

Since a comparatively small group of Latin American and the US teacher educators were invited as participants, our intent is not to overgeneralize the study results to a larger population. Considering the complex nature of the cross-national study involving STEM teacher educators from multiple countries, we employed a purposive sampling technique. Twenty-six (N=26) STEM teacher educators from six countries (Argentina, Brazil, Chile, Colombia, Mexico, and the U.S.) participated in the study (Table 1). Participants were selected based on the following criteria: 1) are STEM teacher educators; 2) are actively involved in pre-and/or in-service teacher preparation; and 3) teach at teacher preparation institutions of higher education. Of the 26 participants, 21 teacher educators are from Latin America and five from the U.S. Overall, the sample is distributed in the following way: Argentina (n=5), Brazil (n=3), Chile (n=5), Colombia (n=4), Mexico (n=4), and USA (n=5). There were 15 female and 11 male STEM teacher educators equally distributed across two major fields: science and science education (n=13), and mathematics and mathematics education (n=13).

Regarding work with a particular population of students, at the time of the study most participants (n=25) taught at the undergraduate level, 16 at the graduate/Master's level and nine at the Doctoral level. Workload distribution (teaching-research-service) among participants varied from 0%-100%-0% (Research professor) to 70%-10%-20% (Adjunct professor) with the most frequent distribution (n=6) of 40%-40%-20% (Assistant professor/Associate professor/Professor). The study participants taught a variety of STEM content, research, and pedagogy courses (e.g., Thermodynamics, Linear Algebra, Calculus, and Physics, Science methods, Mathematics methods, Statistics, Mixed methods research, Research seminar, Education and pedagogy, Curriculum theory, Educational assessment).. Our rationale for the use of a purposive sampling approach takes into account the effects of factors such as Human Development Index (HDI), which includes Research and Development (R&D) investment, and the scholarly productivity of Latin American researchers as reflected in international journals. These interactions are "linked to the relative economic health of the countries of the region" (Ciocca & Delgado, 2017). The teacher educator participants in this study represent the Latin American countries with high scientific research productivity in the region (Brazil, Argentina, Chile, Mexico, and Colombia). Likewise, the volume of science education research by Latin American researchers shows similar standings to those in the scientific disciplines (Medina-Jerez, 2018). This remarkable disparity in research productivity has accentuated not only the gap between developed nations and Latin America but also among the countries of the region. From our perspective,

as education researchers affiliated to an American university with an interest in international studies, the convenience of creating and sustaining a partnership with Latin American universities is based on networking efforts and access to the profile of experts in international academic outlets.

Data sources

The participants completed a 15-item Demographic Survey and a 17-item Professional Journey Survey, both instruments were adapted from the Info-TED University Survey (Czerniawski, Guberman, & MacPhail, 2017). The demographic survey consists of questions on gender, highest degree earned, specialization, number of years in the profession and courses taught, to name a few (Appendix A).

Items in the Professional Journey Survey (Appendix B) were designed to represent the identified phases of participant personal trajectory features and professional practices and demonstrate how STEM teacher educators' personal trajectories transformed and informed professional practices. Participants were provided with a venue to reflect on their own stories about professional trajectories from self-identified cultural, social, and institutional contexts. By considering STEM educator experiences, our purpose was to explore professional practice trajectories for each participant. The data focus was on the STEM teacher educators' self-reported perceptions of their own work as subject specialists with pre- and in-service teachers, with school communities, and with STEM professional organizations.

Data analysis

Data analysis was performed utilizing mixed methods: descriptive statistics (e.g., frequencies, means, percentages, and interrater reliabilities) and meaning coding technique, i.e. semantic deconstruction, to identify trends and thematic categories (Kvale & Brinkmann, 2009; Saldana, 2015), to report common themes and differing teacher educators' practices. Summed item clusters that focus on the same issue tend to be more meaningful and reliable (Gay, Mills, & Airasian, 2009). Teacher educators' narrative responses to the survey were analyzed using open coding (Saldaña, 2015) for the purpose of "breaking down, examining, comparing, conceptualizing and categorizing data" (Strauss & Corbin, 1990, p. 61). To form the analysis, two co-authors reviewed the responses separately and then discussed, coded, and interpreted the data. In the first cycle, thematic coding and analysis were performed and cross-checked. In order to extract common themes, we used frequency counts of similar codes which emerged in the participants' responses. Thematic coding descriptions along with reported frequency counts are included in Table 2. We are cognizant of the small sample size of the study; therefore we purposefully avoided any statistical analysis on the frequency of participants' responses. Phases of professional trajectories were defined using number of years typically used in tenure track process (accepted at most universities) as pre-tenure early career phase (0-5 years), tenure mid-career phase (6-12 years), and late career post-tenure phase (13 years and more).

Table 1.
Participants in the Study

Country	ID	Gender	Discipline	Degree	Job Position	Years in Higher Education/Years as Teacher Educator	College Affiliation	Workload Distribution: Teaching-Research-Service	Semester Teaching Load/Publication Requirement per Year
Argentina	GS	Female	Science Ed	PhD	Assist. Professor	35-11	Engineering	40-40-20	2/1
	CI	Female	Science Ed	MS	Adjunct Professor	22-20	Science	45-45-10	2/1
	AB	Female	Science Ed	MS	Assist. Professor	32-30	Engineering	30-50-20	2/1
	AD	Female	Science Ed	PhD	Adjunct Professor	15-10	Engineering	40-40-20	3/1
	AF	Female	Science Ed	MS	Adjunct Professor	10-10	Engineering	50-40-10	3/1
Brazil	LM	Female	Science Ed	PhD	Professor	11-11	Science (Biol).	30-40-30	3/3
	JM	Female	Education	PhD	Professor	11-11	Education	60-30-10	2/1
	MM	Female	Education	PhD	Graduate Coord.	13-13	Education	30-40-30	3/3
Chile	FX	Male	Math Ed	PhD	Assist. Professor	6-3	Education	30-70-0	2/1
	KO	Male	Math Ed	PhD	Assist. Professor	8-6	Not Reported	30-70-0	1/1
	DS	Male	Math Ed	PhD	Assist. Professor	3-3	Education	0-100-0	2/0
	SB	Male	Math Ed	MS	Adjunct Professor	5-5	Education	0-40-60	5/0
	XH	Female	Engineering	PhD	Assist. Professor	2-2	Not Reported	30-70-0	2/1
Colombia	JU	Male	Math Ed	PhD	Professor	28-22	Education	50-50-0	3/3
	JA	Female	Science Ed	PhD	Professor	35-35	Education	55-45-0	4/0
	AM	Female	Science Ed	BA	Adjunct Professor	10-10	Science & Tech.	70-10-20	3/1
	AL	Female	Science Ed	PhD	Adjunct Professor	25-25	Science & Tech.	50-40-10	5/2
Mexico	HJ	Male	Math Ed	MS	Professor	10-5	Eng. &Tech.	50-25-25	2/1
	SA	Male	Math Ed	MS	Math Ed Coord.	24-24	Eng. & Tech.	40-40-20	6/1
	OS	Male	Math Ed	PhD	Research Faculty	20-5	Eng. & Tech.	30-40-30	4/1
	TT	Female	Math Ed	PhD	Professor	8-4.5	Eng. & Tech.	40-40-20	3/1
U.S	SU	Male	Math Ed	PhD	Professor	28-21	Education	40-40-20	2/2
	IU	Female	Math Ed	PhD	Adjunct Professor	9-20	Education	80-0-20	4/0
	EI	Male	Science Ed	PhD	Assist. Professor	13-13	Education	40-40-20	2/2
	OS	Female	Math Ed	PhD	Assist. Professor	15-15	Education	40-40-20	2/2
	AO	Male	Science Ed	PhD	Assist. Professor	11-11	Education	40-40-20	2/2

In a second analytical cycle, coding identifying patterns and trends by professional trajectory phases was then integrated. Pearson's *r* (Tinsley & Weiss, 1975) as an index was utilized to establish inter-rater reliability. Inter-rater reliability (IRR) is defined as the level of agreement between raters in the context of providing subjective judgments (Tinsley & Weiss, 1975). If raters are in complete agreement, then IRR is 1 (or 100%), and if raters completely disagree, then IRR is zero (0%). There are several methods available for calculating IRR. From the simple (e.g., percent agreement) to the more complex techniques (Tinsley & Weiss, 1975). Two co-authors independently rated each major theme using frequency counts. We employed the Pearson's correlation coefficient r to establish IRR between two raters: r=.8314, r^2=.6912, p=.0204<.05, which is considered as near perfect agreement (Tinsley & Weiss, 1975).

The third cycle of data analysis focused on analysis of specific professional practices and challenges identified by participants. Interpretation of the survey and reflective responses was made first in Spanish—the predominant language of most of the participants, and then shared with participants/researchers to provide feedback on the plausibility of the interpretations made of their views and reported results. The interpreted concepts were translated into English. Clarifying interview questions were posed to participants to reach clarification on key aspects of their accounts. This method resulted in the creation of a multidimensional profile for each STEM teacher educator including, (a) broad standpoint (e.g., country, education institution); (b) controlled environment or perspective (e.g., teaching credential, performance evaluations, the role of the teacher educators in the university and school communities); and (c) specific stance, whereby teacher educators manifest their feelings to their profession.

Table 2.
Themes and Practices

Theme	Practices/Coding Guide	
Mentoring & Faculty Trajectory	**Informal**	**Formal**
Mentoring/professional trajectory is characterized by a sharing of knowledge, experience and wisdom, whether formal or informal, by a peer that leads to improvement of professional knowledge, competence, skill, and effectiveness.	Colleagues; Unassigned Mentee; Consultation, Feedback; Observation/Shadowing Teaching Group; Reflections/ Journaling Professional reading; Watching videos Photos of work	Colleagues; Assigned Mentee, Mentor; Shadowing Feedback; Conferences/Workshops Seminars/Presentations Teaching certifications Coursework; Supervise MA/PhD
Collaboration, Research & Scholarship	**Domestic**	**International**
Peers investigating and sharing to establish facts, new conclusions, making connections to establish cooperative relationships toward an end goal.	Colleagues; Professional; Community Best Practices; Consult/Discussions Teaching Group; Welcomed/Recognition Team member; Making connections Memberships/ Respect; Program review Labs, Projects, Design; Knowledge/Grad. Work; Grant writing	Colleagues; Professional Community; Best Practices Consult/Discussions Recognition; Team Member Making connections Memberships; Respect Labs, Projects, Design Knowledge/Grad. Work; Grant writing
Community Involvement, Leadership and Service		
From the state or service-based position of being perceived as a leader, the power to bring positive, measurable change to both the communities and the university.	Schools; University-Community Centers/projects Education/Extension projects Publishing/ Editor/Peer Reviewer Program coordination/department chair Serving on MA/PhD/College Committees; Advisor Awards Recipient	
Diverse Teaching Practices		
Multiple teaching strategies, educational excellence, effective in addressing **diverse** student needs.	Relatable; Technology integration; Teaching group; Teaching models; new strategies; Dialogue/transformation/meaningful/rigor Practitioner experience; Meet demands of 21st Century; Design new courses Design instructional materials Preparation and planning	

Results

Meaning coding of the survey and questionnaire

As described in the Data Analysis section, we employed meaning coding/semantic deconstruction techniques (Kvale & Brinkmann, 2009) to extract emerging themes describing their professional practices using the TLT framework to explore partici-

pants' transformative learning journeys. First, an open coding procedure was used to identify a list of descriptors of teacher educators' professional practices. Subsequently, descriptors as codes were used to categorize and report emerging themes of professional practices. Major emerging themes included the following: 1) mentoring and faculty trajectory, 2) collaboration and research, 3) community involvement/leadership and Service, and 4) diverse teaching practices (Table 3).

Table 3.
Frequency counts of major themes in teacher educators' professional practices across different career phases

Phase*	Mentoring and Faculty Development	Collaboration, Research and Scholarship	Community Connections, Service and Leadership	Diverse Teaching Practices
EC	25	16	9	22
MC	6	18	8	15
LC	9	12	9	10
Total	40	46	26	47

** Legend: EC: Early Career pre-tenure phase; MC: Mid-Career tenure phase; LC: Late Career post-tenure phase*

Trend analysis by professional trajectory and phases

In this analysis, and in relation to Research Question 1, frequency counts (Table 3) were used to determine trends of major themes in teacher educators' professional practices across different phases in their professional trajectory. The most frequently mentioned themes by participants in the early career phase were Mentoring and Faculty Development and Diverse Teaching Practices. In the mid-career phase, the Diverse Teaching Practices remains as a common theme across participants along with Collaboration, Research and Scholarship. The Diverse Teaching Practices continue to be the common professional practice among teacher educators in the late career phase with Collaboration, Research, and Scholarship. At the same time, we observed changes in particular practices across career phases: for instance, Mentoring and Faculty Development decreased from early career phase to mid-career and slightly increased to the late career phase. An explicitly decreasing pattern was observed for Diverse Teaching Practices. The frequency counts reported above show that there are some observable differences in major professional practices between early and mid-career, whereas there are no observed differences between mid and late professional career phases as reported by STEM teacher educators from participating countries. The TLT point of view allows for recognition of different reference points (in this case, career phases) to identify pathways in professional trajectories.

Trend analysis by country

Next, we looked at the distribution of frequency counts of major themes in professional practices across the six participating countries.

Table 4 below shows that some practices are more frequently used than others across different countries. For example, Diverse Teaching Practices is the most frequently addressed theme by participants in Argentina, Colombia, and USA. At the same time, the theme of Community Connections, Service, and Leadership is the least reported practice by participants from Argentina, Brazil, Chile, Colombia, and Mexico as opposed to the USA. Overall, this result confirmed that there is no observable difference in teacher educators' major professional practices across participating countries.

Table 4.
Frequency counts of major themes in teacher educators' professional practices across participating countries

Country	**Themes**			
	Mentoring and Faculty Development	**Collaboration, Research, and Scholarship**	**Community Connections, Service, and Leadership**	**Diverse Teaching Practices**
Argentina (n=5)	8	11	3	11
Brazil (n=3)	5	6	3	6
Chile (n=5)	6	3	4	5
Colombia (n=4)	6	10	2	10
Mexico (n=4)	5	5	3	5
USA (n=5)	10	11	10	10
Total	40	46	25	47

Professional practices analysis

From the four themes used in the analysis of the data, the following three points are worth highlighting: first, and in correspondence with the STEM teacher education literature (Montenegro Maggio, 2016; Van Velzen et al., 2010), the participating STEM teacher educators declared that they did not receive or participate in induction programs at the beginning of their teacher education careers. Second, they expressed their concern about the quality of their teaching practices, however, this concern declined through time. Third, research and scholarship were perceived as crucial activities that required their attention, especially in the mid-career period. Other observed trends include, Community/School Connections and Service and Leadership were not significantly discussed; Mentoring and Faculty Development needs were highlighted as important in early and late career, and Collaboration, although not highlighted as frequently as Mentoring, Diverse Teaching, and Research, was addressed constantly

in relation to working with colleagues at the beginning of the teacher education career. Collaboration also appeared in reference to Research and Scholarship efforts. In this area, teacher educators described their involvement in research teams and PD programs. They pointed out that they gained and refined their research and teaching skills when they joined projects of this nature.

When looking at the themes by country, Argentinian teacher educators commented frequently on their interest to improve their teaching performance as well as their participation in collaborative projects that involved learning from colleagues, delivering PD workshops, and conducting research. Brazilian teacher educators highlighted their strategies to make their instruction relevant; they even questioned their own instructional practices, were aware of the decline in the amount of resources they need to do their job, and were also concerned with providing a high quality teacher training in the light of precarious socio-economic conditions in their country. Colombian teacher educators alluded to their efforts to make their instruction culturally relevant and to sustain their research and scholarship projects. Teacher educators in the US expressed their commitment to make their research agendas sustainable, support active and meaningful learning, and participate in service and leadership assignments. Teacher educators from the other two countries (Chile and Mexico) commented with similar frequency on their professional practices.

Challenges: Hidden Dynamics

In relation to research question 2, which deals with the challenges that STEM teacher educator encountered in their profession, participants reported a series of issues as obstacles or barriers in the execution of their job-related tasks. We grouped these issues into seven main categories: gender issues and recognition, socio-political influences, cultural and linguistic relevance, financial issues/support, time, value of teaching profession, and low student enrolment in their programs. The issue that mattered the most to participants was making instruction relevant. When describing this factor, they alluded to curricular fragmentation in their courses, to the learning context, their concern with whether their students were engaged and learning, and to the difficulty in translating major ideas into relevant learning tasks informed by research. Next, and not as common as the instructional relevance issue, there was a cluster of challenges that included cultural issues, time, research, recognition, and value of the teaching profession. In the case of cultural issues, teacher educators referred to their students' and colleagues' ways of being as factors impacting their work. In particular, they commented on having difficulties in 'changing' attitudes and personalities that they considered as roadblocks in their work. Lack of time was identified in connection with different job-related assignments. Additionally, not devoting enough time to research, pre-service teachers not having enough time in the field, and lack of time for professional development were also identified as challenges. Other challenges related

to recognition, value of the teaching profession, and research were identified with similar frequency. In these areas, teacher educators felt that their work as educators and researchers was not clearly recognized in respective departments and colleges; they also felt that their programs were not valued across campus. In a similar fashion, they shared their concerns about their profession and discipline not being valued in the wider academic community. Challenges in research included issues pertaining to the design of settings (classroom/department/college) to promote research—which they noted as an aspiration to elevate the quality of their programs. Other challenges, although receiving less attention, were significant in that they reflect current issues affecting the political stability of their countries. This type of challenge was shared by participants from Argentina, Chile, and Brazil. Two more issues in this low frequency cluster include gender (difficulties working with male colleagues), financial issues getting in the way of professional development opportunities, and low enrolment in their programs.

Discussion and Conclusions

The purpose of this cross-national study was to investigate the professional trajectories and practices for professional growth of STEM teacher educators based on theoretical underpinnings of TLT in five Latin American countries and the US.

TLT facilitated identification of teacher educator transformations unique to each individual and akin to each other in their roles in academia. With respect to the first research question, addressing the extent to which STEM teacher educators' professional practices vary across countries, a relevant common finding was the fact that all the participants reported not being part of an induction program at the beginning of their teacher education career. This result corresponds with studies conducted in other multi-national contexts highlighting motivation as "self-initiated, intrinsic, and dependent on personal needs" to grow professionally (Malm, 2020, p. 353). In the absence of a mentoring program, most of the participating teacher educators resorted to finding a mentor within their colleagues or to maintaining the mentor-mentee relationship they had established prior to being appointed to their teacher education position (Hargreaves, 1994) or to the experiences they accumulated in their former roles as teachers (Czerniawski, 2018). Furthermore, and although not presented as a common set of strategies among the participants from a particular country, there was some discussion of those approaches to securing a good start at the onset of their teacher educator career in the role of facilitating the subject of teaching. Without support for a continuous professional pathway and encouraged by their own identity as good teacher educators with an aim to continuously improve (Alexandersson, 2016), they implemented teaching practices that in their views were innovative —again, research concerns did not surface until their mid-career phase. These practices aimed to make their instructional practices comprehensible, attractive, and effective. Some teacher educa-

tors took advantage of the strong professional relationship with their informal mentor by 'inheriting' an abundance of materials and resources that they modified according to the needs in their courses. Differences in experience seemed to be associated with the adopted practices. Those with a more individualized approach became creative in supporting their constant reflection by taking pictures of the information they displayed on the board and using it as a sort of informal assessment exercise or as fruitful teaching methodology to be deployed again in future courses. Others in their early career reminisced about their prior experiences as students in classes where instructors seemed to succeed in creating interest and involvement among the students. The same teacher educators shared a simple strategy like watching videos of effective teaching in their attempts to create engaging classes. A few teacher educators used the revenues from their workshop delivery to support their own faculty trajectories. Some found opportunities for professional growth in their interactions with students and colleagues.

These contexts and situations presented themselves as resources for teacher educators to work collaboratively by questioning their own practices and assumptions towards curricular programs that they viewed as outdated and fragmented. Perhaps, and like Cochran-Smith (2003) put it, these teacher educators' professional career is enriched when they inquire about their professional knowledge and practice. Either individually (Colombian) or collaboratively (Argentinian), participants exercised their agency in re-structuring their curricular programs. Despite failing to get the support from colleagues, some teacher educators drew on their own disciplinary expertise to propose new courses, add research-based components to education programs, or work in conjunction with personnel from other departments and with their own students to produce innovative audio-visual materials to promote course content and student work.

Another important finding in relation to variations in professional practices across countries was noted in STEM teacher educators' contributions from three countries (Argentina, Chile, and Brazil). In their reports and by reflecting on what makes their individual identity (psychoanalytic view of TLT), they commented on the impact that in their views, socio-political factors afflicting their countries have on their work. They were concerned with their return to the classrooms after weeks of revolt or wondered about how to deal with issues of violence that have infiltrated their university campuses, and yet dealing with major budget cuts that have left them with few resources to carry out their work. These are tensions and challenges teacher educators across the globe face daily. These circumstances attest to what Murray (2014) terms as teacher educators' professionalism being relational. In his view, professionalism results from the intricacy in relationships among the actors (teacher educators), their work environment, and the context (unstable working conditions). As for the case of feeling disempowered by the lack of resources, they alluded to becoming more politically engaged either to regain what they have lost or to secure the few resources they still have avail-

able. When comparing Latin America and the US, there were not notable differences, still teacher educators in the US regarded research, diverse teaching, and leadership as their most significant themes.

With regard to professional practices at different career phases, the observed variation was in the emphasis they placed on the two most commented themes (diverse teaching practices and research) at different career intervals. It seemed like the goal, at the beginning of the professional trajectory was to gain momentum in the mastery of their teaching skills as new teacher educators (early-career), and then engage in and develop their scholarship work once they felt comfortable with their teaching (mid-career). This finding is consistent with results in Montenegro Maggio's (2016) study of Chilean teacher educators' professional paths. With the exception of two teacher educators, they described themselves first as teacher educators playing multiple roles. As the focus on the quality of their instructional practices declined, there was a raise in their awareness at mid-career, about the attention they should give to the research and scholarship area. This finding could be explained on the grounds of being experts in a specific field but not having previous school teaching experience (Griffiths, Thompson, & Hryniewicz, 2014), which is the case of some participants. There were the cases of teacher educators that, although having the schoolteacher experience, were not prepared to work with adults (Smith, 2003). All the participants asserted that their professional practices as teacher educators were in an emerging state because they needed to adapt to new challenges in their careers. It was noted that between the early- and mid-career phases, they perceived themselves as teacher educators and researchers. This observation changes to teacher educator, researcher, and teacher of teacher as they transitioned into their late career.

Regarding the research question addressing the challenges the participating teacher educators faced in their professional practices, the findings reveal that the issue the participants were most concerned about was making their instruction relevant. In early career, they were interested in 'changing student attitudes and personalities' in relation to the mastery of content. They also wondered whether their students were having a meaningful learning experience in courses. These concerns seemed to originate from their roles as 'second-order practitioners' (Kelchtermans et al.,, 2018), that is being responsible for the teaching of a subject discipline at the onset of their teacher education career. Less frequent challenges included the difficulties in making their classes culturally responsive, having to showcase your work constantly to gain recognition among your colleagues, advocating across campus in favour of the teaching profession which they reported as not valued by faculty members in other colleges/departments. In the same cluster of challenges, teacher educators referred to struggling with their attempts to modify their students' outdated learning behaviours, students refusing learning, certain learning formats, or not participating more actively in their own learning. This cluster belongs to the early-career group who seemed to exercise practices consistent

with teacher educators with experience as schoolteachers and little research experience who are more apt to display pragmatic practices (Berry & Van Driel, 2013). Most teacher educators found themselves dealing with numerous tasks that left them with little time to focus on their research. Recent studies suggest that this trend has an international occurrence. Studies in other latitudes have reported that teacher educators are concerned with lack of time and heavy workloads that limit their chances to grow in their profession (Van der Klink, Kools, Avissar, White, & Sakata, 2017; MacPhail et al., 2018; Czerniawski, 2018). There were also some challenges discussed sporadically: the difficulties some female teacher educators had in working with and getting recognition from their male colleagues and the concern with the low enrolment in the education programs.

Teaching is a complex activity (Cochran-Smith, 2003), and because teacher education practitioners bring with them diverse backgrounds, experiences, and expertise (Kelchtermans, Smith, & Vanderlinde, 2018), tracing a professional path becomes a complex task. Czerniawski (2018), contends that "making generalizations about the work they [teacher educators] do is challenging" (p. 9). This difficulty arises from the varying understanding of teacher education at the local, national, and international levels. It is suggested that a more appropriate posture is to view through a TLT lens teacher education as a journey that at each critical juncture, takes the STEM teacher educator to different contexts and probably to assume different sub-identities. Here, it is important to note the following: first, an important finding in this study, particularly in the professional practices of teacher educators from Latin America, indicates that their identities are more focused on the teaching practice rather than on the scholarship area. This finding is in correspondence with Montenegro Maggio's (2016) study of Chilean teacher educators' professional paths. Second, the lack of support during the teacher-to-teacher educator transition period was a common feature among the participants. This lack of support presupposes the adoption of varying approaches and sub-identities that can explain why teacher education looks different in each locality. Third, for the participants, their teaching education journey begins with an assumption that as teacher educators they should excel performing that task. This emphasis becomes less apparent by the time they reach their mid-career phase. Then, the attention is devoted to their scholarship activities. Having gained some expertise in the crafts of teaching and researching, the teacher educator seems to feel more competent and whole as a teacher educator doing research. This delayed attention to this area can be explained by, as teacher educators from other nationalities put it, scholarly activities that include reading research, conducting research and writing require more time. In sum, findings of our study concur with outcomes in international research, suggesting that for teacher educators to develop professionally they must have an intrinsic motivation (affective disposition). Malm (2020), points out both positive (self-esteem, fostering student teachers' personal and professional development) and negative factors

(heavy workload and lack of time and opportunity for scholarly activity) as the drivers of a central aspect of being regarded as good teacher educators, which is the willingness to seek continuous improvement. Utilizing a TLT lens allowed the researchers to view different participant identified impacts, including personal, social, cultural, and educational that define their reflection of their professional practices and professional trajectories.

Synthesizing the main findings, the study reveals that the lack of support during the teacher-to-teacher educator transition period was a most common feature among the participants. Findings also document that the participants' professional journey begins with an assumption that as teacher educators they should primarily excel in performing their teaching task. It is particularly evident in the professional practices of teacher educators from Latin America where their identities are mostly related to the teaching practice rather than to the scholarship.

Limitations

It is acknowledged and accounted for in this research study that STEM teacher educators change over time, that knowledge, practices, and attributes are involved in these changes, and that the situated positions of teachers contributed to these changes. Our analysis did not account for the faculty transition across higher education institutions (or tenure at a single institution) in terms of impact on professional trajectory, due to a lack of demographic data collected in this area. It is, also, acknowledged that there are other theoretical underpinnings which could have been recognized and utilized, but it was felt those frameworks were more appropriate to future extension of this research. Lastly, although the sample size was small and participants were recruited through purposive sampling, we feel the sample represented appropriate diversity to fully address the research questions and provide adequate generalizability of the findings. Results could be confirmed with future research employing an expanded random sampling.

Future research and recommendations

Based on participant responses, research based on STEM teacher educator learning outcomes and connections to the emerging construct of socio-political-economic characteristics of globalization of STEM education requires further research. Additionally, the data collected suggest a need for research in the area of measuring the impact of professional trajectories on professional identities for STEM teacher educators. Using learning trajectories for theoretical guidance, it would be appropriately reflective of learning trajectory research (Sztajn, et al., 2012) with in-service teachers to identify how STEM teacher educators' learning trajectories inform their teaching practice and instruction.

Working in collaboration with international STEM teacher educators and col-

leagues contributes to becoming aware of new teaching methodologies commonly used in other institutions, which in turn can enrich and expand the views and knowledge base of each participant. As a means of building a community of practice approach, expanding the research to other international colleagues and exchanging our views and approaches to teacher education as a method of data collection and analysis. This can lead us to analyse our professional practices and professional trajectories and rethink the kind of professional educator we want to prepare, how to contextualize teacher education, and the focus we would like to build to improve STEM teacher education in the United States from the cross-national perspective.

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Appendix A.
Teacher Educator Demographic Survey
(Adapted from Info-TED University Survey)

1. Name:
2. Gender:
3. Country and City of Residency:
4. Highest Degree Earned:
5. Field: ___ Science Education, ___Math Education, ___Other
6. Current Position:
7. Do you work at a: ___Public, ___Private Institution, or ___Both?
8. University Name:
9. College Name:
10. Department Name:
11. Do you work with: ___Undergraduate, ___Graduate, or ___Doctoral Students?
12. Number of years as a teacher educator:
13. Number of years as a university faculty:
14. Please, name the courses you usually teach:
15. What tasks are you expected to fulfill as part of your job?

_____ Teaching

- Number of courses taught each semester: ____
- Number of students you work with each semester: ____

_____ Research

- Number of papers you are expected to publish each year _____
- Number of proceedings you are expected to publish each year____
- Are you expected to publish textbooks/monographs: __Yes, __No
- Are you expected to publish book chapters: __Yes, __No
- Are you expected to pursue external funding: __Yes, __No
- Other:

_____ Service

- What internal activities are you currently involved in?
- What external activities are you currently involved in?
- Other:

What is the distribution of these tasks? (I.e., Teaching (40%), Research (4%), Service (20%)

Appendix B.
Professional Journey Survey

1. What was your motivation to become a teacher educator?
2. What was your route to become a teacher educator?
A. Through academia: Earning a PhD or Master's degree?
B. Through classroom teaching: A successful and experienced teacher becomes a teacher educator
C. Other
3. What group of teacher educators do you fell identified with?
A. Teacher educator as a schoolteacher
B. Teacher educator as teacher in higher education
C. Teacher educator as researcher
D. Teacher educator as teacher of teachers
4. Consider your professional career before entering the teacher education profession. Do you feel like holding on to your identity as a schoolteacher or as a practitioner in your field prior to your current job?
5. At the beginning of your teacher education career, were you assigned to work with a mentor?
6. If assistance/mentoring/induction was/was not provided, what strategies did you use to feel competent in your work?
7. Describe the beginning of your teacher education career. What stands out? What things did you learn by doing? Any changes you made to meet the demands of your job? Over the years, have you gone through an experience of transformation in your views as a teacher educator?
8. What are the main challenges you have encountered in your teacher education career? How have you dealt with them?
9. Is your work as a teacher educator being impacted by other [internal/external] forces that take your focus/energy away from the work you want to do?
10. What are the main accomplishments in your career as a teacher educator?
11. What is the ultimate goal of if your work as a teacher educator? Is that goal aligned with your vision and mission as a teacher educator? If not, how do you reconcile that mismatch?
12. In a broad sense, how possible do you think your work is? That is, preparing a range of individuals who become teachers who can in turn enable an enormously diverse group of students?
13. Has your work as a teacher educator changed over the years? In what ways? How are you coping or adapting to those changes or new challenges? For instance, as an experienced teacher educator you may be dealing with new pressures to maintain high status.

14. What are your major priorities in your professional development? (e.g., acquiring pedagogical content knowledge, enhancing scholarship). What strategies are you implementing to achieve the desired goal or performance level?
15. What activities are you leading in your community that in your opinion are contributing to your professional growth?
16. Where do you get the support you need to grow as a professional teacher educator?
A. Self-support (e.g., working in the field with pre-service teachers)
B. Community support (e.g., a new curriculum, workshops)

17. In your institution and based on your personal professional needs/goals, what opportunities for professional growth should be available?
A. Higher academic degrees
B. Workshops and seminars outside the institution
C. Staff development inside the institution
D. Feedback on teaching
E. Voluntary and forced support
F. Peer tutoring
G. Other?