

Article

Transdisciplinary Teacher Education

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Abstract: This position paper proposes that teacher education programs should shift from preparing teachers who are consumers and perpetuators of grand narrative knowledge to teachers who are creators and knowers of transdisciplinary (TD) knowledge and perpetuators of a TD narrative. To that end, the Nicolescuian TD methodology, especially epistemology, was introduced as a new grounding for knowledge that can lead to transdisciplinary teacher education. This paper explores what teacher education might look like through a Nicolescuian TD lens with its innovative focus on epistemology—the knowledge required to function in a complex, modern world confronting wicked problems. As this is currently a nascent and untested idea, recommendations for future research are suggested (practice, policy, and theory).

Keywords: teacher education; transdisciplinarity; epistemology; grand narrative; transdisciplinary narrative

1. Introduction

Formal training and socialization into an education career path are normally the purview of university *teacher education* programs that graduate bachelor's degree students who qualify for government certification to teach in the public and private education sectors. Clandinin and Husu [1] recently expanded teacher education to comprise a continuum “from initial/pre-service teacher education to in-service teacher education and professional development [and] many kinds of teacher education programs and practices” (p. 6).

In the call for papers for this Special Issue of *Education Sciences*, Lucey [2] suggested that teacher candidates are chosen because they “possess the abilities to affirm the dominant narrative and the values that it presents” (para. 1). This candidate selection process is informed by “the discipline of epistemology [which concerns] a society's generally accepted basis for knowledge” [2] (para. 2) (i.e., the dominant narrative). Epistemology is a branch of philosophy that concerns what counts as knowledge and knowing [3]. Lucey called for “a reframing of the principles that define the basis for knowledge” [2] (para. 5) with transdisciplinarity (TD) proposed herein as one possible lens. “Transdisciplinarity is generally defined by the inclusion of non-academic stakeholders in the process of knowledge production” [4] (p. 1). TD extends the concept of *knowledge* far beyond what is espoused by individual disciplines (e.g., education, economics, sociology, sciences, law, psychology).

At issue herein is the assumption that teacher education candidates are expected to perpetuate (affirm) the dominant *grand narrative*, which is unfortunately grounded in an epistemology that alone does not favor a sustainable future [5]. The grand narrative is a set of modern ideas that most people take for granted and do not question. These ideas include capitalism, top-down globalization, competition, win-lose mentality, scarcity mentality, survival of the fittest, patriarchy, science, technological progress, success and materialism, and consumerism. The grand narrative, usually linked to the mainstream or status quo, profoundly affects the way society is organized, peoples' roles in that society, and the power relationships among institutions in that society, including between the education system and the world [6,7].

Preparing educators who will steep the public in an epistemology that creates and perpetuates the wicked problems arising from the grand narrative is not a sustainable



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proposition. This type of teacher education fails society and the future. Examples of wicked problems include “corporate-led globalization, unsustainability, climate change, global warming, refugees and forced migration, loss of biodiversity, arable land and potable water, health inequality, poverty and insecurity, violence and terrorism, and uneven human and economic development” [8] (p. 1). These problems “are ill-structured, multicausal and involve multiple stakeholders. What worked before will not work again because the context is different. Attempts to address them often spawn new wicked problems with the original issue actually changing because people tried to fix it. There is no guarantee or even assumption that a solution is possible or recognizable, but *something* must be done” [8] (p. 1) (see also Rittel and Webber [9]).

A certain epistemology is required to ensure that the grand narrative prevails—that privileged sites and privileged knowledge endure and dominate [2]. The dominant epistemology stems from positivism and empiricism, which holds that truth and reality can only be found using deductive, exclusive logic and the objective scientific method. Science and technology prevail over the arts and humanities [5]. This position paper proposes that teacher education programs should shift from preparing teachers who are consumers and perpetrators of grand narrative knowledge to teachers who are creators and “knowers of knowledge” [7] (p. 373) who perpetuate TD knowledge. Transdisciplinarity’s profoundly different perspective on epistemology and knowledge can shed a powerful light on this idea and pave the way for a TD narrative to replace the grand narrative [10].

Transdisciplinary epistemology is all about complexity [5,11]. Nearly 80 years ago, Rivlin [12] defined teacher education as “the broad professional preparation needed for the highly complex task of teaching in a modern world” (p. 793). Khosrow-Pour [13] more recently recognized that “the constantly changing landscape of Teacher Education makes it challenging for experts and practitioners to stay informed of the field’s most up-to-date [innovations]” (p. XX).

These persistent, time-spanning observations inspired this exploration of what teacher education might look like through a Nicolescuian TD lens with its innovative focus on epistemology—the knowledge required to function in a complex, modern world confronting wicked problems [5]. After briefly defining teacher education and providing a more detailed discussion of Nicolescuian TD (especially TD epistemology), this position (expository) paper elaborates on what transdisciplinary teacher education might look like through a Nicolescuian TD lens (i.e., TD teacher education, TD narrative, TD curriculum philosophy, TD learning process, and TD mind habits).

Ideas herein follow on nascent, earlier work by McDowell [10] in 2012 and Paige et al. [14] in 2008. Paige et al. brought TD to in-service secondary science education practice but not to teacher preparatory education. Broadly speaking, a TD approach would help teachers “tackle . . . complexity [and] challenge knowledge fragmentation [by bringing] complexity to classroom practice when there is also the need to develop conceptual understanding, skills in the synthesis of ideas from a number of discipline [and sector] areas, and dispositions to want to take social and environmental action” [14] (p. 24). In an expository piece, McDowell [10] speculated that transdisciplinary teacher education is possible prefaced with a cautionary note: “reconfiguring education is complex and uncertain” (Slide #7).

2. Teacher Education

Good [15] described teacher education as “all the formal and informal activities and experiences that help to qualify a person to assume the responsibilities of a member of the educational profession or to discharge [their] responsibilities more effectively” (p. 586).

Teacher education comprises philosophical, theoretical, pedagogical, practical, and professional components [16]. The intent is to help pre-service teachers (PSTs) acquire knowledge they would apply when teaching. Teacher education also concerns a developmental process wherein PSTs augment their human potential by gaining knowledge, skills (capabilities), values, attitudes, and behavior patterns conducive to a professional teaching career [16].

Grossman et al. [17] recognized the divide between educational (philosophical) foundations and methods courses (two key components of teacher education programs) and called for the integration of knowledge (epistemology), skills, and professional identity. “Teacher education needs to respond to the changing requirements of the society at large . . . and ignite a will in teachers to commit to developing themselves” [18] (p. 5). How PSTs see themselves as educators (perpetrators or challengers of the grand narrative) is important. The philosophical (epistemological, foundational) aspect of teacher education is thus of interest in this paper because these programs should prepare PSTs who can adapt their educational philosophies to the latest scholastic trends [19]. Transdisciplinarity, which challenges the grand narrative, is introduced as an intellectual innovation with relevance to teacher education and PST preparedness. TD is a philosophical and epistemological concept [20].

Educational Philosophies

Well-structured teacher education programs intentionally orient PSTs to the philosophical underpinnings or foundations of education [17]. A philosophy is a belief system that guides life and professional decisions and behavior [8]. Educational philosophies reflect assumptions about and shape perceptions of (a) the purpose of education and a particular educational program; (b) what content is of value and worth learning; (c) how students learn; (d) what material, methods, instructional strategies, and resources to use to teach them; and (e) how, when, and by whom learning should be assessed and evaluated [21,22].

Over the past century, educational philosophers have proffered a collection of educational philosophies: perennialism, essentialism, academic rationalism, curriculum as technology, cognitive learning processes, self-actualization, progressivism, social reconstructivism, personal/global, and existentialism [22–24]. These philosophies can be categorized as teacher-centered, student-centered, or macro-centered (i.e., focused on society, nature, and humanity) [25]. Ideally, PSTs are exposed to these educational philosophies and taught to appreciate that each one informs their approach to teaching differently [17,21].

Transdisciplinarity is not an educational philosophy, but its tenets can be applied to education, as McGregor [8] recently demonstrated. Transdisciplinarity is a methodology, an approach to creating new knowledge that is grounded in four philosophical axioms (i.e., presuppositions about what counts as knowledge, reality, logic, and the role of values). TD augments longstanding methodologies: empirical, interpretive, and critical [26]. Because this Special Issue concerns how the discipline of epistemology informs the teacher candidate selection process and what successful candidates are taught [2], this next section explains the transdisciplinary methodology (especially TD epistemology) followed by inaugural thoughts on what teacher education might look like viewed through a TD lens.

3. Transdisciplinarity

Trans means across and beyond [27]. *Transdisciplinary* means between, across, and beyond all disciplines. This beyondness includes governments, the private sector, the public sector, and civil society. In the 1970s, transdisciplinary was coined as a new word (a neologism) to express the idea that addressing complex, wicked problems using just knowledge from the academic disciplines (mono-, multi-, and interdisciplinarity) was insufficient. Other ways of knowing and creating knowledge are required with their integration imperative. Solving today’s complex, wicked problems require “the unity of knowledge” [5] (p. 201) instead of relying on only one source of knowledge.

A theoretical quantum physicist, Basarab Nicolescu drew on the new sciences of quantum physics, chaos theory, and complex systems theory to formulate his approach to transdisciplinarity. While acknowledging the role of academic disciplines and conventional methodologies, Nicolescu [5,11] formulated a TD *methodology* comprising three philosophical axioms (ontology, logic, and epistemology) with ongoing discussion about the merit of the fourth axiom, axiology (values) (see McGregor) [3,26]. Transdisciplinarity assumes that the knowledge required to deal with the polycrises facing humanity is best formed from

the creative amalgamation of humanity's learning and knowing from all sectors, not just the academic sector.

3.1. TD Ontology

Many perspectives and consciousness are competing to be heard during TD knowledge creation. Governments approach an issue from a different stance than industry, and different levels of government and industry sectors take different stands. The military holds different ideas than the general public. Civil society brings layers of positions held by many different sectors and institutions (e.g., family, health, education, environment, labor, legal). There are also generational differences (children, youth, adults, seniors), cultural differences, and gendered differences. Coming to mutual understandings of each other's point of view is deeply complex and challenging.

Respecting this situation, Nicolescu [5,11,28] formulated a TD ontology comprising multiple levels of Reality (he capitalizes reality), and the Hidden Third. This was a major innovation from the longstanding classical physics' assumption that there is one reality that can only be fully discovered by using the scientific method (the crux of the grand narrative).

For Nicolescu, Reality exists along two major dimensions: internal and external. Internal Reality is called the *TD-Subject* and represents the flow of consciousness, awareness, and perceptions. It includes individual (philosophical and psychological), social and cultural, political and ideological, and historical levels of Reality. External Reality is called the *TD-Object* and represents the flow of information, facts, and statistics. It includes economics (business and law), environment (ecology), technology (also science and medicine), planetary, and cosmic (universe, multiverse) levels of Reality [5,11,28].

Movement between, among, and beyond these many levels of Reality is mediated by what he called *the Hidden Third* (like a third party moderating contentious negotiations). Mediation is required because each level of Reality has its own take on the world, and the meeting of divergent minds to address complex wicked issues needs lubrication to get things started, move things along, and wrap things up. The melding of subjective consciousness and objective facts needs help. In Nicolescu's [5,29] opinion, this Hidden Third constitutes religions and faith, spirituality, the sacred, culture, and the arts. These are not realities; instead, they cross all Realities. They constitute the invisible unifier, the mind-opening and "spirit-opening modalities" that make it possible for integration to occur, leading to new TD knowledge (as described in an email from Eric Reynolds, 15 August 2018).

Nicolescu [30] said this work occurs in the *zone of nonresistance*, meaning people remain open to each other to facilitate temporary engagement to address a common concern. Their experiences, intuitions, reflections, interpretations, descriptions, representations, images, and formulas *meet* in this mediating zone of nonresistance. He proposed that using music, art, theatre, dance, drama, connections with nature, and other avenues of aesthetic, spiritual, and sacred expression smoothed the edges, so that people could begin to connect. The Hidden Third thus serves as a way for divergent actors to temporarily set aside their positions so they can reach common middle ground for the sake of the common good. This requires a special kind of logic (habits of the mind) [11].

3.2. TD Logic

People who assume that a meeting of the minds is not possible when there are intractable contradictions tend to use *exclusive logic*. This makes it permissible to *exclude* opposing and incompatible ideas (another part of the grand narrative). On the other hand, TD embraces *inclusive logic*—called the *logic of the included middle*—because divergent minds come together on *neutral* middle ground [11]. Movement among the multiple levels of Reality (i.e., the meeting and commingling of opposing minds, values, attitudes, perspectives, viewpoints, and world views) is assumed to be possible and very desirable because people can avail themselves of a logic that does not preclude anything. Everything is considered because an inclusive approach can engender insights leading to solutions to

complex problems [31]. “All views on the problem must be included and any contradictory positions must be temporarily reconciled so strategic and innovative solutions to the problem can be formulated, agreed to and implemented” [3] (p. 194).

To accommodate the emergence of complex new knowledge, Nicolescu [11] also formulated the *logic of complexity*. Inclusive logic “deals with reconciling contradictory and antagonist ideas so new facts, thoughts, and insights can emerge. [Complexity logic] helps people weave these new disparate strands of thinking into a complex new whole [to which all agree]” [31] (p. 4). It “lets people cross and connect different ways of knowing and perceiving in creative and coherent ways” [31] (p. 5). The logic of complexity also enables people to (a) have their own truths, knowledge, and models of the world, while at the same time (b) appreciating that there are limits to this knowing. They must be willing to re-evaluate their way of knowing each time they use it and reinvent their truths, knowledge, and models of the world if necessary [32]. “Transdisciplinary logics better ensure the creation of ‘more complete’ knowledge to address the complexity [of the situation]” [31] (p. 5).

3.3. TD Axiology

Knowledge creation has long been associated with values. Each of the three conventional research methodologies has an axiology axiom. Empiricism is value-neutral. Interpretive is value-laden. Critical is value-driven [3,26]. But Nicolescu [5,29] eschewed the need for a TD axiology, claiming instead that the TD values that emerge during the TD knowledge creation process in the included middle are more important than the values people held when they entered the process. He was convinced that values are derived (originate) or are engendered from the other three TD axioms during their interplay in knowledge creation. Examples of common TD values are humility, sensitivity, honesty, respect, transparency, and an appreciation for complexity as well as for messiness and chaos. People come to trust that order *is* emerging just not predictably.

McGregor [33] challenged this philosophical stance arguing that the deep exchanges that occur during TD knowledge creation raise the issues of value accommodation and value reconciliation. A value disconnect can block the unity of knowledge so valued by Nicolescu [11]. McGregor maintained that “values have to be respected, managed and led [because] they are often the missing link to strategic solutions” [3] (p. 193). Axiology concerns what is important to people and worthy of their attention. Values clarification can help identify one’s prejudices and biases that can contribute to resistance and pushback to other actors’ positions and ideas. Values analysis can reveal others’ value schema [26,33]. The axiology axiom for knowledge creation concerns “how people think and perceive things and *why* rather than *what* they are thinking with the former deeply shaping the latter” [3] (p. 194).

3.4. TD Epistemology

This paper reflects the need for a new grounding for epistemology in teacher education [2]. Of special interest is how Nicolescu [11] formulated TD epistemology. He drew heavily on Edgar Morin’s [34,35] work on complexity thinking, which inspired Nicolescu’s [11,28,29] idea that TD epistemology comprises complexity, emergence, embeddedness, and cross-fertilization. Succinctly, transdisciplinary “knowledge creation occurs in the fecund middle ground where contradictory perspectives are set aside (people temporarily give up sovereignty) to create a space for the intellectual fusion and integration of ideas and perspectives leading to the emergence of new, [embodied] TD knowledge” [3] (p. 188).

McGregor [26,36] used a lava lamp metaphor to help explain TD epistemology as formulated by Nicolescu [5,11]. The base inside the lava lamp represents the undulating, moving floor of the included middle, where people from many sectors step into the *zone of nonresistance* to problem solve together using *inclusive* and *complexity logic*. Their interaction across many *levels of Reality* (subjective internal and objective external) is lubricated and mediated by the *Hidden Third*. The heated, moving wax (lubricant) in the lava lamp contributes to the *emergence* of new TD knowledge.

To elaborate, as people (ideas, perspectives, world views, and so on) brush against and bounce off each other during the problem-solving exchange, new ideas develop, interact, and so on via bursts of intense energy until something new bubbles up to the top of the lamp. This emergent, *cross-fertilized* knowledge bubble created through intellectual fusion, synergy, and synthesis then falls back into the flow and lands on everyone, thus making the new knowledge *embodied* (i.e., a part of everyone involved). The resultant TD knowledge arose from a temporary reconciliation of divergent world views. Everyone now owns this embodied knowledge and is inclined to steward and use it to problem solve. Boundaries that temporarily came down to facilitate a meeting of the minds may stay down, or they can be put back in place per the dynamics of the particular cohort of actors [36].

Finally, Nicolescu [11,28] drew on complex adaptive systems (CAS) theory to help formulate TD epistemology as *complex*. CAS are adaptive, self-organizing, and capable of operating at the edge of chaos where order emerges, just not predictably. Ant hills, traffic flows, animal swarms, and stock markets are examples of CAS. They exhibit the features of coherence, self-organization, self-direction, bottom-up emergence, entanglement, productive tension, and leverage [37,38]. McGregor [3] succinctly explained that TD knowledge is considered “*complex* because the people and systems that were involved adapted and reorganized. Their behaviour emerged from a few simple rules applied locally, with far reaching effect. Order in the knowledge creation process emerged without central control. Small changes were allowed to leverage big effect. And, the people involved trusted that things could emerge from unpredictable events (chaos theory)” (p. 193).

TD Hermeneutics

Van Breda [39] was concerned with how the TD knowledge creation process is impacted by what the wicked problem *means* to different people. How actors are interpreting the situation strongly informs their positions and their asks. Inspired by this innovation, another layer of Nicolescu’s [40,41] TD epistemology pertains to *TD hermeneutics*, a neologism first coined by van Breda [39]. *Hermes* was the Greek god of communication, speech, writing, and eloquence [27]. His job was to interpret (explain the meaning of) the other gods’ messages and share that interpretation with humans. The concept of hermeneutics thus refers to the art of interpretation to discern intended meaning so communication can ensue [42].

In the context of TD knowledge creation by a collection of diverse actors holding varying points of view, TD hermeneutics involves listening to others to discern their meaning while remaining open to discordant ideas. Nicolescu [11] envisioned the unity of knowledge. That unity cannot happen if people cannot hear each other so true understandings can emerge. TD hermeneutics “manifests in the fusion of prejudices and perceptions leading to more powerful understandings of self and others” [3] (p. 192).

New TD knowledge can emerge when people move beyond previously held viewpoints and meld their knowing with that of others. TD hermeneutics accounts for how to avoid deadlock when disparate minds are engaging for a common cause [11,42]. These deadlocks (i.e., complete standstill and blockage to mutual *meaning making*) can occur when people encounter confusion, ignorance, dissimilar use of familiar words, overuse of jargon, resistance, arrogance, anger, and fear [5,33]. Sorting through these roadblocks is easier if people can remain open to appreciating where others are coming from and what the whole thing means to them—TD hermeneutics.

In summary, Nicolescuian transdisciplinarity encompasses multiple levels of Reality (subjective internal and objective external) whose flow and movement are mediated by the Hidden Third. People from a wide array of disciplines and sectors enter a zone of nonresistance to each other’s ideas and temporarily use inclusive and complexity logics to create new TD knowledge that is cross-fertilized, emergent, embodied, and very complex. The TD values engendered in this process facilitate meaning making and knowledge integration, leading to innovative and mutually accepted ways to address wicked problems.

4. Nicolescuian-Informed Transdisciplinary Teacher Education

McDowell [10] queried, “Is transdisciplinary teacher education possible?” and answered with “a cautious ‘yes’, both in principle and in practice” (Slide 14). It would mitigate the possibility of preparing PSTs for a bygone era [10] whose perpetuation depends on them affirming the grand narrative [2]. This paper advanced Nicolescuian transdisciplinarity as a way forward. What might TD teacher education look like through a Nicolescuian lens?

4.1. Transdisciplinary Narrative

McDowell [10] proposed that teacher education should instill a *complex TD narrative* to push back against the grand narrative. Similar to Nicolescu’s [5,11] TD methodology and epistemology, PSTs would learn that a TD narrative includes (a) dialectical elements that foster discussion of opposing ideas, (b) an interpretive framework for emergent and unfolding contexts, (c) countering persistent discipline-specific teachings while appreciating their valid contributions, and (d) appreciating the power of cross-fertilized learning and knowing. It would socialize PSTs to (e) value uncertainty, chaos, and complexity; (f) strive for personal emergence and educational transformation; (g) esteem the contributions of generalists and specialists; (h) embrace self-directed, self-determined, negotiated, and collaborative learning; and (i) respect the evolution of their identities as TD-informed and TD-inspired educators [8,10].

4.2. Transdisciplinary Curriculum Philosophy

Drawing insights from McGregor’s [8] discussion of what constitutes a transdisciplinary curriculum philosophy, transdisciplinary teacher education programs would further assume several key things about teacher education. Foremost, PSTs would learn that TD-informed education is based on four pillars: (a) learn to *know/learn* (gain depth, breadth, and diversity of knowledge, learn how to learn); (b) learn to *do* (take action, apply knowledge); (c) learn to *live* together (communicate, resolve conflicts, employ cultural sensitivity; appreciate interdependence); and (d) learn to *be* (self-esteem, self-knowledge, self-autonomy) (see also Delors) [43].

Second, PSTs would learn that instead of assuming intelligence is located in a single mind, they would come to appreciate that it is spread over people, places, time, and distance—called *distributed intelligence*. Third, the learning process is alive instead of stopping when something is learned. In addition to information retention and integration into one’s mental schema, learning involves intuition, imagination, and sensitivity. Therefore, the original learning is simply a springboard for *translearning*. Fourth, instead of the teacher education program inculcating grand narrative values, PSTs would be taught (a) value clarification of their own values, (b) value analysis of others’ values, and (c) a deep respect for values integration into new constellations [8]. In this process, they would be taught to critique the grand narrative (and its underlying ideologies and paradigms) rather than accept it as given [44].

Fifth, PSTs would learn that no discipline is privileged. All disciplines have something to contribute, so learning them is worthwhile. But disciplines cannot address wicked problems in isolation because too many voices are excluded. Paige et al. [14] claimed that preparing people for transdisciplinary teaching requires them to be disciplinary before being transdisciplinary. Once admitted to a teacher education program, PSTs should thus be oriented to (a) conventional educational foundations and philosophies [25], (b) their disciplinary content specializations, and (c) Nicolescuian TD knowledge creation and epistemology [45].

Sixth, PSTs would come to learn that TD learning spaces are both within and beyond the conventional classroom setting. These spaces represent where the wicked problem is playing out in real time. Thus, learning groupings also extend beyond the teacher education program to include the rest of the world [8].

4.3. *Transdisciplinary Learning Process*

Following McGregor's [45] lead (steeped in Nicolescuian TD), a TD-oriented teacher education program would sensitize PSTs to two additional factors: TD learning and TD habits of minds. Related to TD learning, Davies [46] creatively presumed that "disciplines are opportunities to explore different ways of thinking" (p. 1) rather than blocks of knowledge that are clearly delineated by boundaries (see also Nicolescu [29]). This assumption lets teacher education programmers intentionally socialize PSTs to challenge the grand narrative and its requisite disciplinary epistemology [2]. PSTs would learn the insightful power gained from lowering borders between disciplines and other societal sectors' ways of knowing to expand their TD learning and knowledge creation.

In efforts to internalize and perpetuate a TD narrative [10], PSTs would also learn that knowledge creation is "a social, negotiated and iterative process [stemming from] the integration of a diversity of disciplinary [and other sectoral] perspectives" [47] (p. 726). PSTs would be taught to break down the traditional boundaries between disciplines and sectors to create new, integrated intellectual frameworks instead of relying solely on disciplinary epistemology [48]. They would share their content/disciplinary-specific information with other PSTs in the teacher education program, so they can cocreate new TD knowledge [47].

Moreover, both TD learning and creating TD knowledge are socially accountable and reflexive, meaning PSTs would learn to take into account the effect of their values, biases, prejudices, and political or ideological positions as they learn to be educators [47] (i.e., reflexivity). PSTs in the teacher education program would also become a community of learners working for a common cause rather than just a collection of people learning together [49]. They would learn to "effectively communicate across disciplines and sectors, value others' expertise and knowledge, establish necessary relationships, ask important questions, integrate shared learning, and grow in self-confidence while successfully [learning] with others" [50] (p. 1). TD learning is a powerful way to socialize PSTs to challenge the dominant narrative with a TD narrative.

4.4. *Transdisciplinary Mind Habits*

On a final note, Nicolescuian TD epistemology (knowledge creation) depends on transdisciplinary logic (inclusive and complexity). Logic is habit of mind [11]. Other scholars have also engaged with the idea of TD habits of mind, and their thinking has merit in this paper. Mishra et al. [51] identified seven universal habits of the TD mind: perceiving, patterning, abstracting, embodied thinking, modeling, playing, and synthesizing. These are the cognitive skills people tend to use when they are creatively thinking across a range of domains and sectors. Such people are naturally inclined to integrate different perspectives and viewpoints rather than dismiss them (see also Mishra and Koehler [52]). Rather than assume PSTs have this skill set, transdisciplinary teacher education programs should intentionally teach it.

Derry and Fischer [53] also discussed TD mindsets and competencies. By their account, PSTs would need both (a) disciplinary-specific, in-depth knowledge and (b) a TD mindset comprising three elements: knowledge about boundary objects, a commitment to TD learning communities, and metacognitive skills that foster a reflective TD learning community. Boundary objects include journals, standards, research, and conferences. They serve to connect ideas across people. Metacognition refers to teaching PSTs how to think about and monitor their own thinking, because this habit supports reflection and reflexion. They must be skilled at reflecting on their mode of participation and inquiry, data, concepts, theories, ideologies, and the activities within their TD learning community [53].

"In a transdisciplinary teacher education programme, . . . the students and teachers work together across disciplines, languages and contexts to integrate approaches and perspectives. Besides local and contextual knowledge, [PSTs would learn to respect] globally relevant knowledge, perspectives and competences" [18] (p. 4). Transdisciplinary teacher education would thus allow PSTs to "establish links between [sic] persons, facts, images, representations,

fields of knowledge and action, to discover the Eros of learning during our entire life and to build beings in permanent questioning and permanent integration" [30] (p. 10).

5. Recommendations for Future Research

McDowell's [10] 2012 discussion of transdisciplinary teacher education was speculative and not grounded in any particular approach to transdisciplinarity. He concluded that transdisciplinary teacher education is possible both in principle and in practice. The neologism of transdisciplinary teacher education informed by Nicolescuian TD [5,11], especially epistemology, was thus introduced in this paper. It is a nascent idea right now—just coming into existence and beginning to develop (see [10,14]). There is no research on this topic. Education scholars are encouraged to take up the mantle to critically determine if the idea herein has merit (quantitatively and qualitatively). Several recommendations are tendered for future research initiatives.

5.1. Practice

- Researchers should develop a profile of the world's array of teacher education programs, which exist along a continuum [1,13]. Using this information, scholars could explore how people using these various approaches to educating PSTs react to the idea of drawing on Nicolescuian TD (especially epistemology) to create transdisciplinary teacher education. Most pressing, what are their thoughts on recruitment strategies and curricular changes?
- This position paper developed the idea of Nicolescuian-informed transdisciplinary teacher education, but it has not been implemented. Concrete, empirical information would help move this idea from an expository position (well-reasoned argument) to evidence-based praxis. Education researchers should thus explore the challenges faced by teacher education programs (and in-service professional development) relative to embracing this new direction. Also, what risks were associated with using this approach in teacher education? And what opportunities and solutions were considered or developed? McDowell [10] considered some of these issues, but not empirically. Paige et al. [14] used transdisciplinarity in their in-service secondary school science education experiment, but it was not Nicolescu's [5,11] methodology, and they did not focus on teacher education.
- This paper suggests that Nicolescu's [5,11] formulation of TD epistemology can create teachers who are producers and creators of knowledge, not just users (consumers) of knowledge. In the event that universities embrace the ideas herein, future scholars could engage in primary research around how this shift impacts educators and influences their practice.
- This paper proposes that Nicolescuian TD [5,11] can inform teacher education relative to challenging the grand narrative, leading to the TD narrative [10]. In the future, education scholars are encouraged to explore whether this claim can be empirically supported.
- Should universities begin to reorient their teacher education enterprise from a Nicolescuian TD [5,11] perspective, it is imperative their efforts be studied to discern the criteria they identified and applied to screen candidates' predisposition to reject the grand narrative or be willing to critically question it. Codifying and standardizing their pioneering initiatives would pave the way to increased uptake of this idea.

5.2. Policy

- Lucey [2] implied that "the discipline of epistemology" (para. 2) shapes educational policy—both public school and higher education. He challenged the field to explore new groundings for knowledge that can inform education, schooling, and teacher preparation. This paper introduced Nicolescu's [5,11] TD methodology, especially epistemology, as a new grounding for knowledge that can lead to transdisciplinary teacher preparation. Education policy (informed by epistemology) determines cur-

ricular content and pedagogy. Policy affects what teachers are taught to teach and how [10]. Some education scholars may thus be interested in studying the education policy implications of shifting to transdisciplinary teacher education.

5.3. Theory

- This paper recounts Nicolescu's [5,8,11,45] TD methodology for creating new knowledge and proposes that it could be applied to teacher education. Future researchers should begin to theorize the Nicolescuian-informed transdisciplinary teacher education phenomenon. Theorizing would move the discourse beyond speculation and an expository stance (position paper explaining a series of very complicated ideas and speculating their import in praxis) to an educational theory replete with assumptions, defined concepts, and a network of propositions proposing how the concepts are related to each other to explain the phenomenon.

6. Conclusions

Paige et al. [14] proclaimed that bringing transdisciplinarity to teaching is the “only ethical and educational direction we can [take] in order to make a difference in the lives of . . . the next generation of educators” (p. 31). Guided by this ethical imperative and inspired by Lucey's [2] assumptions about the discipline of epistemology's impact on the basis and grounding of knowledge for teacher preparation, Nicolescuian TD-oriented transdisciplinary teacher education recruitment criteria should screen for PST candidates who seem to be predisposed to push back against the dominant grand narrative rather than perpetuate it. Once admitted, curricular innovations should recognize and augment the transition from uncritically parroting the grand narrative to consciously espousing the TD narrative [10].

In a powerful commentary, Rigolot [4] asserted that, when done well, transdisciplinarity becomes “a way of being, it is inseparable from personal life and extends far beyond professional activities” (p. 1). With transdisciplinary teacher education, pre-service teachers can learn about the process of creating knowledge using Nicolescuian TD epistemology, which in turn enables them to better espouse and teach the TD narrative to offset the dominance of the grand narrative. Teachers socialized into this imperative can expose future generations to a powerful epistemology (i.e., what counts as knowledge, knowing, and how that knowing is acquired). Citizens thus taught can consciously choose to use Nicolescuian transdisciplinarity to confront the complex wicked problems that plague humanity, thereby displacing the dominant grand narrative with the TD narrative. Teaching education programs thus informed would be the vanguard for the future.

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