A Complex Systems Perspective on Policy Standards for Teacher Learning and Development

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Abstract

In the United States, the Interstate Teacher Assessment Consortium (InTASC) Standards and Learning Progressions inform pre-service teacher curricula and in-service teacher professional development and evaluation policies (Council of Chief State School Officers, CCSSO, 2013). We apply a complex dynamic systems (CDS) lens to analyze the Standards document's ontological assumptions about the nature of teaching and teachers' professional learning. Our inductive and model-guided content analysis revealed that the Standards' representation of effective teaching highlights the contextual and iterative, feedback-driven nature of teacher learning and change. Teachers' learning is described as non-linear and as requiring qualitative reconfigurations of expertise. The development of critical teaching dispositions reflects processes typically associated with identity system exploration. These ideas are congruent with complex dynamic systems theories of teachers' learning and identity formation such as the Dynamic Systems Model of Role Identity (DSMRI). We derive two conceptual behavioral landscapes for teachers' practices and for their means of learning. We close by proposing that the findings underscore the importance of partnerships among researchers, practitioners, and policymakers in the use, application, and revision of policy.

Keywords: teacher learning, teacher evaluation, complex systems, learning progressions

OVERVIEW

Teacher education and professional development are domains of continuous debate. Scholars, policymakers, administrators, teacher educators, and teachers themselves grapple with the kinds of knowledge, skills, beliefs, values, goals, and learning experiences

needed to prepare teachers for diverse and ever-changing professional contexts. In the United States, a remarkable collaboration among groups of education practitioners, researchers, and policymakers has led to the publication of teaching standards that provide guidance for what constitutes exemplary teaching practice at varying levels of expertise. The document, known as the *Model Core Teaching Standards and Learning Progressions for Teachers* 1.0 (hereafter referred to as Standards) was produced by the Interstate Teacher Assessment and Support Consortium (InTASC) of the Council of Chief State School Officers (CCSSO, 2013). It can serve as an important point of reference for pre-service teacher education as well as in-service teacher professional development (CCSSO 2013; Darling Hammond & Bransford, 2007; Gitomer & Bell, 2013; Mihaly, Caffrey, Staiger & Lockwood, 2013). Its interpretation, use, and application have the potential to shape local educational agency directives and affect the lives of practitioners and students.

Education policy documents such as *Standards* aim to inform various communities of practice including teacher educators, school leaders, and professional development (PD) designers and evaluators. Historically, these communities have relied on research that depicts teacher learning and change as based in linear and distinct relations among constructs such as teacher beliefs, attitudes, skills, and behavior, and student and teacher outcomes (Russ, Sherin & Sherin, 2016). Although this approach has contributed to knowledge regarding the importance of various factors in initiating or sustaining teacher change, it fails to describe how these various factors interact in authentic educational settings, undergird the emergence or hinderance of qualitatively new and adaptive teacher practices, and shift in response to personal and contextual events over time. The important aim of *Standards* was to address such gaps through describing the scope and progression of the teacher's role in general and prescriptive terms. The document conveys a perspective about the nature and goals of teaching, how teaching skills change over time, and how these should be evaluated. Yet, does the *Standards*' perspective correspond with the traditional epistemologies that have guided teacher education and PD for decades, or does it reflect the new approaches to teacher learning and practice that view them as contextualized, complex, and dynamic emergent phenomena? Explicating the ontological assumptions that frame this potentially impactful policy document may have important implications for its interpretation and use.

In this article, we examine the assumptions about teaching and teachers' learning in *Standards*. Our goal is to analyze *Standards* through a Complex Dynamic Systems (CDS) lens, and then consider the implications of the findings for educational researchers, practitioners, and policymakers whose predominant paradigm so far has relied on linear, process-product teacher learning frameworks. We begin by summarizing the content of *Standards*; elaborate on the CDS approach and its application to teachers' learning; and then present an empirical analysis of the assumptions underlying *Standards* and their

correspondence with assumptions of complexity. We conclude by using the findings to offer avenues for new theoretical conceptions of teaching, and directions for research on teacher learning from a complexity perspective, with the hope that each may contribute to knowledge about the facets of effective teaching (Goldman, Graham, Cohen-Vogel & Schmidt, 2017).

The Model Core Teaching Standards and Learning Progressions

Published in 2011, updated in 2013, and created by a committee in which 20 national teaching organizations were represented, The Model Core Teaching Standards and Learning Progressions document outlines "what teachers should know and be able to do to ensure every PK-12 student reaches the goal of being ready to enter college or the workforce in today's world" (CCSSO, 2013, p.3). *Standards* is intended to serve as a state and local level resource for the development of "policies and programs to prepare, license, support, evaluate, and reward today's teachers," (p.5). Summarized in Table 1, the standards in the document are grouped into four categories that reflect contemporary research on effective teaching (Darling-Hammond & Bransford, 2007). The categories are The Learner and Learning, which includes teachers' focus on understanding students' developmental and individual differences; Content Knowledge, pertaining to deep disciplinary and pedagogical knowledge and its application; Instructional Practice, which focuses on teachers' planning, implementation, modification and assessment of students' learning activities; and Professional Responsibility, which encompasses teachers' own professional learning, growth, and leadership capacity. Within the document, the operationalization of each standard is achieved through three key indicators: performances, defined as observable behaviors and practices; essential knowledge, which includes declarative and procedural knowledge that supports practice; and critical dispositions, which include the teacher's psychological "habits" and "commitments" that support practices (CCSSO, 2013, p.6). The content within each standard specifies the actions the teacher should take and provides an insight into ideal underlying goals, beliefs, and assumptions from which such actions emerge.

In its 2013 revision, the *Standards* authoring committee included a detailed account of how these indicators might manifest at an initial stage, an intermediate stage, and a mature stage. The stages are introduced in a Rationale Statement and are called learning progressions— "descriptions of the successively more sophisticated ways of thinking about a topic" (National Research Council 2007, p. 214). The learning progressions reveal the Committee's thinking about how teachers' learning occurs (Schneider & Plasman, 2011); they "describe the increasing complexity and sophistication of teaching practice for each core standard across three developmental levels" (CCSSO, 2013, p.10). Significantly, the learning progressions are intended as "a type of rubric in that they consist of descriptive

criteria against which a teacher or coach can compare performance and make formative judgments to support a teacher's growth" (p.10). Table 2 provides an example standard and its associated learning progression within the category of teacher content knowledge.

Table 1
Summary of the Model Core Teaching Standards

Category	Standard	Definition
The Learner and Learning	1. Learner Development	The teacher understands how learners grow and develop, recognizing that patterns of learning and development vary individually within and across the cognitive, linguistic, social, emotional, and physical areas, and designs and implements developmentally appropriate and challenging learning experiences.
	2. Learning Differences	The teacher uses understanding of individual differences and diverse cultures and communities to ensure inclusive learning environments that enable each learner to meet high standards.
	3. Learning Environments	The teacher works with others to create environments that support individual and collaborative learning, and that encourage positive social interaction, active engagement in learning, and self-motivation.
Content Knowledge	4. Content Knowledge	The teacher understands the central concepts, tools of inquiry, and structures of the discipline(s) he or she teaches and creates learning experiences that make these aspects of the discipline accessible and meaningful for learners to assure mastery of the content.
	5. Application of Content	The teacher understands how to connect concepts and use differing perspectives to engage learners in critical thinking, creativity, and collaborative problem solving related to authentic local and global issues.
Instructional Practice	6. Assessment	The teacher understands and uses multiple methods of assessment to engage learners in their own growth, to monitor learner progress, and to guide the teacher's and learner's decision making.
	7. Planning for Instruction	The teacher plans instruction that supports every student in meeting rigorous learning goals: drawing upon knowledge of content areas, curriculum, cross-disciplinary skills, and pedagogy, as well as knowledge of learners and the community context.
	8. Instructional Strategies	The teacher understands and uses a variety of instructional strategies to encourage learners to develop deep understanding of content areas and their connections, and to build skills to apply knowledge in meaningful ways.

Category	Standard	Definition
Professional Responsibility	9. Professional Learning and Ethical Practice	The teacher engages in ongoing professional learning and uses evidence to continually evaluate his/her practice, particularly the effects of his/her choices and actions on others (learners, families, other professionals, and the community) and adapts practice to meet the needs of the learner.
	10. Leadership and Collaboration	The teacher seeks appropriate leadership roles and opportunities to take responsibility for student learning, to collaborate with learners, families, colleagues, other school professionals, and community members to ensure learner growth, and to advance the profession.

Source: CCSSO (2013); Authors' summary.

Although the notion of learning progressions could be interpreted as evidence of an assumption that teacher learning is linear, serial, and additive, two uses of the term "complexity" are present in the introductory portion of the *Standards* document. In the first, the committee contends that the progressions "describe the increasing complexity" of teachers' practice as they move from novice to expert" (CCSSO 2013, p.10). This statement reveals an assumption that novice or beginning teachers' practice, knowledge and dispositions may be less complex in nature than their senior counterparts, although the document does not elaborate on the definition of complexity, whether complexity would be apparent to an observer or the teacher themselves, and whether it remains an underlying process from which particular practices emerge. In the second use, where key assumptions that underpin the learning progressions are described, the authors state that "learning and teaching are complex" and there is an acknowledgement that teaching takes place in "a fluid and organic environment" (CCSSO, 2013, p.11). The document also refers to the need to attend to the fact that teachers operate in environments where they have limited resources, which could indicate an opportunity to examine system constraints.

The document does not offer further insight into whether the committee viewed teacher development as being epistemically complex (i.e., as hard to know about or understand) or as ontologically complex; that is, whether it can be characterized as a complex dynamic system (Van Geert & Steenbeek , 2014). In the current analysis, we examine the utility of considering teacher development as the latter, and analyze the *Standards* document accordingly, using a framework that views teachers' learning as manifesting ontological complexity.

Table 2

Excerpt from a Teaching Standard and Learning Progression

Learning Standard 5. Application of Content		
The teacher understands how to connect concepts and use differing perspectives to engage learners in critical thinking, creativity, and collaborative problem solving related to authentic local and global issues		
1. The teacher connects concepts, perspectives from varied disciplines, and interdisciplinary themes to real world problems and issues.		
Level 1	Level 2	Level 3
	And…	And…
The teacher helps learners see relationships across disciplines by making connections between curriculum materials in a content area and a related perspective from another content area or areas.	The teacher collaborates with a colleague(s) in another discipline(s) to create learning experiences that engage learners in working with interdisciplinary themes. S/he guides learners to apply knowledge from more than one discipline to understand a complex concept or set of concepts and/or to address a real world problem or issue.	The teacher engages learners in identifying real world problems, or themes then can explore through projects, using their acquired and expanding knowledge and skill in the content area.

Source: CCSSO (2013, p.28).

Complex Dynamic Systems

Complex Dynamic Systems (CDS) is a scientific approach that arose in the mid-twentieth century from a recognition of "organized complexity" in natural and social systems—systems in which many interrelated parts interact with reciprocal and unpredictable ways to give rise to emerging patterns of orderly behavior by the system as a whole (Weaver, 1948). In a complex system, phenomena are comprised of networks of interdependent elements whose continuous, iterative interactions produces the system's overall behavior (Guastello & Liebovitch, 2009). Unlike simple "clockwork" systems that comprise few elements or elements that connect to each other in a linear and non-variable manner, the connections among elements in a complex system are reciprocal and interdependent, such that the behavior of a system cannot be understood by reducing it to its components (Yoon, et al., 2019). Complex systems change through iterative processes that sometimes involve small changes and stable overall patterns of behavior, but at other times involve large scale modifications to the structure and behavior of the system. CDS research spans a variety of theoretical and methodological perspectives, and has been applied to diverse educational phenomena including student attendance and achievement, classroom interactions, self-regulated learning, teacher identity formation, and teacher

professional development (Garner & Kaplan, 2017; Garner & Russell, 2016; Jacobson, et al., 2016; Koopmans, 2017; Pennings, et al. 2014).

As scholars have considered complex systems in regard to teaching and teachers' learning, a number of critical ideas have appeared. One is that simultaneous, reciprocal or parallel interactions among elements of a system result in the nonlinear emergence of self-organization, which yields persistent, adaptive behavior for the system in its particular context (Gell-Mann, 1994; Holland, 2006; Opfer & Pedder, 2011). When the system describes an individual, this means that the person's knowledge, beliefs, skills, and emotions can interact in simultaneous (co-acting) and reciprocal (mutually influencing) ways (Kaplan & Garner, 2017). When the system refers to the classroom, this means that teachers and students can influence one another in reciprocal and unpredictable ways (Opfer & Pedder, 2011). Moreover, systems are nested within one another (Jacobson, et al., 2019); an individual teacher's psychological system resides within the system of the classroom and within the system of the school, which itself resides as a system within the macrolevel societal system. Activity in one level of the system, or unit-of-analysis, can cause changes at other levels.

Systems exist in high and low probability states which can be represented conceptually, and in some cases mathematically, as an undulating behavioral landscape (Gell-Mann, 1994; Kelso & Zanone, 2002). Systems tend to exhibit stability in high probability configurations and states and become destabilized when forces or parameters "push" them away from their preferred patterns of behavior. The process of learning has been interpreted as involving a perturbation or destabilization of the system, leading to an exploration of other, possible states and system configurations into which the behavior of the system eventually settles (Newell, et al., 1991). Teacher learning may therefore manifest periods of stability and periods of relative disorganization or instability. Contextual factors of importance may also influence which particular knowledge, skills, behaviors, and attitudes are more or less likely to occur and persist over time. These factors may be constrained by particular foci or attractors that keep the teacher's system behaving in a certain way.

Teacher Learning as a Complex System

Opfer and Pedder created a powerful, complex systems lens through which teachers' learning can be viewed. They proposed three overlapping and recursive complex systems: the teacher system, the school system, and the activity system. The teacher system focuses on an intraindividual unit-of-analysis similar to cognitive approaches to teacher learning (Kagan, 1992) and conceptualizes learning as an opportunity for teachers to reflect on prior and new experiences, and on changes that might be made within the teacher's particular context. The school system speaks to the sociocultural approach by positing the school as

a learning organization that, to a greater or lesser degree, creates a safe environment in which teachers can learn. It operates at the collective unit-of-analysis described by collective knowledge, beliefs, and pedagogical norms. The activity system emerges through the interaction between the individual—the teachers and students—and the school systems. It includes both the individual's and the school's orientation to learning, but it emphasizes reciprocal relations whereby teachers' instructional practices influence and are influenced by the context in which they occur. Thus, a complex systems approach embraces reciprocal relations and does not force one view or unit of analysis over another. It is sympathetic both to the contextualization of phenomena at the individual teacher or classroom level and to the generalization of contextualized phenomena to the activity of entire systems. This is a weakness of dominant models that do not explicitly articulate the ways in which reciprocality exists between teachers' everyday practices and their learning and separate rather than integrate individual and collective level changes (Wei, et al., 2010). The assumptions behind complex systems approaches to teacher's learning and change are sensitive to both the contextual peculiarities of teaches' learning and the search for common patterns and trajectories of development across individuals, contexts, and time (Opfer & Pedder, 2011).

Analyzing Standards as a Complex System

The three interrelated systems articulated by Opfer and Pedder are reflected in the Dynamic Systems Model of Role Identity (DSMRI; Kaplan & Garner, 2017), a CDS informed metatheoretical framework that can be applied to teachers' learning and professional development. The DSMRI conceptualizes teachers' learning as involving iterative shifting and emergent reconfiguration among intraindividual, role identity-salient constructs organized into four categories. These include 1) self-perceptions and definitions, 2) purpose and goals, 3) ontological and epistemological beliefs, and 4) perceived action possibilities. Each is associated with emotions and ultimately leads to action. This system of interrelated constructs is situated within a set of control parameters that include the teacher's enduring psychological dispositions, the psychosocial context of the classroom, and other sociocultural contexts of the school and broader society[1]. The interrelations between identity components and the context gives rise to the individual's actions in a particular role (such as teacher). Actions are carried out within particular social roles and social contexts and are executed in light of the individual's beliefs, in alignment with values, and

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[1] The DSMRI and the *Standards* document refer to dispositions and critical dispositions respectively. The DSMRI treats dispositions as relatively enduring personality traits and characteristics such as extraversion, openness to experience, need for cognition, or anxiety (Kaplan & Garner, 2017). The *Standards* document defines critical dispositions as temporally stable "habits of professional action and moral commitments that underlie [teachers'] performances" (CCSSO, p.6).

in service of a goal. From the perspective of the DSMRI, teaching actions would be observable if one were to witness the teacher enacting the performances mentioned in the Standards document. The DSMRI has been used to examine the nature of learning in professional development settings, and has revealed iterative, reciprocal, contextually situated learning within and across subject matter domains (Garner & Kaplan, 2019; Hathcock et al., 2020). The model is shown in Figure 1.
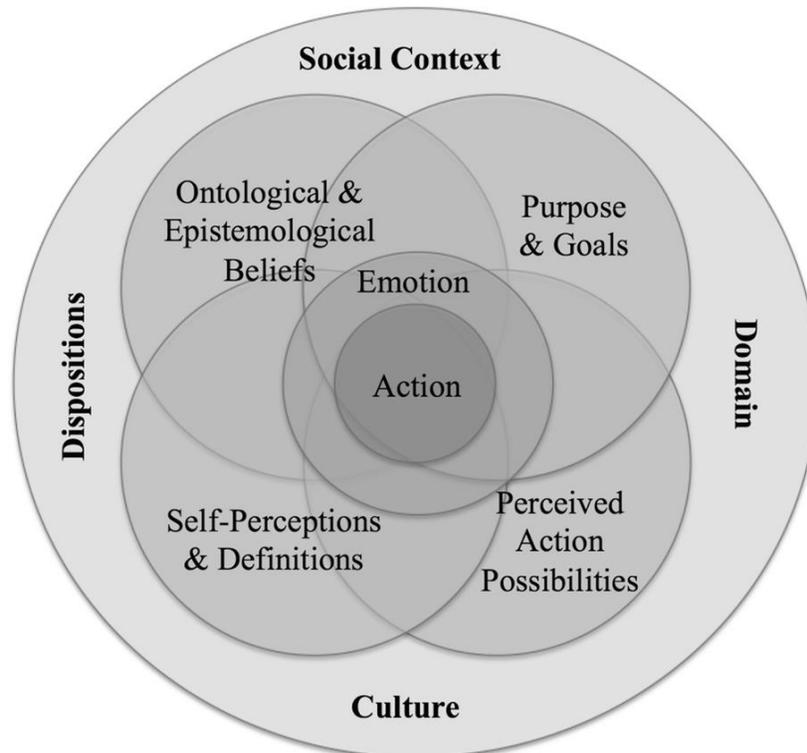

Figure 1. The Dynamic Systems Model of Role Identity
(adapted from Kaplan & Garner, 2017)

Within the DSMRI the teacher-in-context is portrayed as a nested system. The role-identity as a teacher is nested within the individual's overall identity system, as well as within the sociocultural context of the school, district, and broader geographical-political contexts. In the outer circles of the diagram, social context, culture, domain, and dispositions act as control parameters on the identity system of the teacher that, as they vary, stabilize or destabilize the content, structure, and relations among identity system components (Henry, 2016).

For example, a science teacher may participate in professional development (PD) designed to deepen knowledge in the area of research design and performances of rigorous experimental methods once back in the classroom. Participation may impact their self-

perceptions as an expert in science, but not their critical dispositions of goals for teaching and beliefs about the ways in which students learn (or are incapable of learning) science. Without considering how new disciplinary knowledge influences their goals or practices, the teacher may experience little change (i.e. stability) in their perceived action possibilities (the performances key indicator) once back in the classroom and continue to teach as before. Alternatively, another teacher participating in the same professional development may strengthen their knowledge of science methods, but may pay particular attention to the pedagogical strategies used during the PD. New teaching role performances enacted within the context of the PD may lead the teacher to reflect on their developing commitments and their existing habits or critical dispositions, as well as their ontological beliefs about the nature of science and the nature of learning. For this teacher, a small change in science content knowledge due to participation in learning activities that are an integral part of the PD may produce a cascading effect of changes in beliefs, goals, and action possibilities for the classroom.

Applying the DSMRI to *Standards*

Because the DSMRI can be used to understand changes in the constructs and components of teachers' learning and provide insights into the interrelations among constructs and processes, we propose that it can offer insights into the categories and learning progressions in *Standards* (Garner & Kaplan, 2019). As an impactful policy document, *Standards* constitutes a multifaceted cultural artifact, and hence must be examined for ways in which it articulates consensual expectations about teachers' learning. Its different facets can then be identified to reflect different kinds of control parameters—primarily reflecting the DSMRI's domain and culture control parameters. For example, statements regarding teachers' required content knowledge can be identified as a domain control parameter that shapes the teachers' construction of individual teacher role identity, such as their content knowledge and their beliefs about the kind and level of content knowledge that they should possess as effective teachers, and their self-perceptions regarding this knowledge and the match of their interest and efficacy in relation to this knowledge. In comparison, statements regarding indicators of effective teaching would be identified as elements of the culture control parameter, and as scaffolds for teachers in the process of developing and honing their content-related knowledge, skills, self-perceptions, and professional goals.

The DSMRI can also examine the epistemological complexity of the teacher's identity and learning system by examining action possibilities (e.g. a particular instructional strategy), beliefs (e.g. about the characteristics of particular contexts for teaching), goals (e.g. towards self-improvement in a particular domain), and self-perceptions (e.g. self-efficacy for a particular aspect of teaching) included as critical dispositions within the

Standards document. Viewed this way, the included examples of enduring psychological characteristics should start to reveal alignments between identity components, and progressions in knowledge, performances and critical dispositions through identity and self-constructive processes such as exploration and commitment (Day, et al., 2005; Kroger & Marcia, 2011).

Research Questions

The primary aim of the document analysis is to examine *Standards* for its ontological assumptions about teacher learning and professional action. A second purpose is to apply a complex systems approach to the assumptions in *Standards* and consider the ways in which specific CDS perspectives on teachers' learning and change might reveal factors that are germane to researchers and practitioners who design and evaluate teacher professional development.

Specifically, our research questions were:

1. Does the content of the Teaching *Standards and Learning Progressions* document map onto a complexity approach to teaching and teachers' learning?
2. How might a complex systems approach to teachers' learning and change augment understanding of the *Teaching Standards and Learning Progressions*?

METHOD

Analytical Approach

This study employed a theoretically guided document analysis (Bowen, 2009), which can provide tentative answers to questions that then frame future research activities (Prior, 2003). In the role of analyst, the researcher conducts a document analysis according to a three-step, iterative process involving skimming, close reading, and coding and interpretation. We followed the guidelines of Bowen (2009) in creating the protocol for the content and thematic analysis, and Zhang and Wildemuth (2009) in structuring our qualitative inductive (data-guided) and deductive (model-guided) analysis of content. In order to promote trustworthiness of the findings, the first author conducted the document analysis and the second author acted as an auditor, conducting an independent critical reading of the document, the analysis, and its interpretation (Creswell & Plano Clark, 2011).

Data Source

The data source was the document *InTASC Model Core Teaching Standards and Learning Progressions for Teachers 1.0*, i.e., *Standards*, retrieved from https://www.ccsso

.org/sites/default/files/2017-12/2013_INTASC_Learning_Progressions_for_Teachers.pdf

The Introduction and Summary sections at the beginning of the document were included in the analysis of assumptions, as the document states that those sections describe "what the standards are and what they hope to achieve" (p. 5). The section that follows includes the learning progressions, which describe "the increasing complexity and sophistication of teaching practice across a continuum of development" (p. 5) and provide insight into the Committee's assumptions behind teachers' growth. The third section of the document provides details about the standards and learning progressions, including the three key indicators (performances, essential knowledge, and critical dispositions). The fourth section includes a glossary and a chart of 15 cross-cutting themes aligned with those key indicators. The document ends with the names of the committee members who created *Standards*.

Procedure

For the first research question, we adopted an inductive approach to identifying assumptions within *Standards* and then synthesized these thematically. We began by analyzing the Introduction and Summary sections for imperatives describing what teachers need, must, or are required to do. Imperatives were coded as revealing consensus assumptions about the nature of effective teaching as agreed upon by the *Standards* committee. Statements were aggregated by imperative and synthesized thematically. Three categories of imperative emerged from this analysis: *contextual adaptability, an iterative approach to improving practice,* and *deliberate self-improvement* (Table 3). Next, this process was repeated for the learning progressions. Statements within the Rationale section of *Standards* were analyzed for terms describing the nature of teaching. We were particularly interested in documenting terms that might reveal assumptions of ontological complexity when referring to the nature of teaching. The key terms that emerged were *complex, not linear, feedback, context, reciprocal, iterative, shift, fluid, additive,* and *synthesis* (Table 4).

To address the second research question, we adopted a multi-step analytical approach. First, we counted frequencies of several conceptual categories within each of the performances key indicator to reveal areas of greater or lesser emphasis. Close reading of the entire set of performances led to the emergence of a tentative question that was then applied to each of the individual performances: For whom, in what way(s), and how (or when) is the teacher effecting professional practice? This led to three foci for the teachers' performances: *the learner, the content,* and *the context* (Fernandez-Rio, 2016). We used these foci to build a graphic representation of a three-dimensional space where, for each one, the axes reflected the presence or absence of a topic. The axes of the three-dimensional space represent the factors underlying the teachers' performances. The frequencies within

the various regions of the representation reflect (prescriptively) higher and lower probability areas of the "effective teacher" system (Figure 3). At the aggregate level, the three-dimensional representation reflects ways in which the performances collectively focus on the learner both in and out of context, and on the learner both with and without content.

To better understand the contextual parameters surrounding how the various activities included within the performances were thought to change as teachers developed expertise over time, we analyzed the verbs and the targets of each of the the teacher action statements. Two themes emerged. The first theme was *teacher agency*, which varied from low, when the teacher's accomplishment of a learning objective was required or otherwise instructed, to high, when the teacher's achievement was encouraged for the purpose of individual or collective mastery. The second theme was the scope of the *context*, which ranged from an immediate or classroom context to a broad school or community context. The themes were used to organize the activities and create a contour chart (Figure 2) to depict the relative emphasis on these as the learning progression level increases. A contour chart depicts a 3-D topographical representation of a landscape viewed from above, with darker colors reflecting higher concentrations of behaviors. The resulting figure provides a visual cross-reference of actions as they were coded for low or high teacher agency and aimed at an immediate versus broad context. We then used a parallel strategy, in which each statement for each standard was read and coded according to the document's treatment of the conditions and purposes in which teachers should learn. This analysis revealed themes according to whether the intended learning and change was to take place individually or as part of a collective such as a learning community, and also whether the content of teachers' learning should focus on the classroom context or on the broader context of the school and its community. We used a contour chart to visualize the resulting landscape of teacher learning strategies for each Standard area (Figure 4).

The final step in the analysis was to examine the definitions portions of the *Standards* document, and critical dispositions in particular for evidence of role identity components and processes (Table 5), including references to processes that might promote teachers' system stability or the emergence of new ways of thinking and behaving as a teacher (Table 6). We used the role identity components and processes included in the DSMRI—specifically, we looked for examples of self-perceptions and definitions (to include values), purposes and goals (for teaching), ontological and epistemological beliefs (about the nature of learning and the nature of teaching), and action possibilities (to include ways in which the teacher should demonstrate their knowledge and skill). Finally, we drew on process indicators of identity change such as exploration and commitment, and examined the ways in which *Standards* include these as strategies for developing new ideas, beliefs, and

actions. Exploration and commitment development are includes as identity processes within the DSMRI (Kaplan & Garner, 2017).

FINDINGS

Our findings are organized by research question and theme. The first research question explores underlying assumptions about the nature of teaching and teachers' learning, including the *Standards* document's characterization of effective teaching and the development of experti se in teachers. The second question focuses on applying the complex systems concept of a landscape to reveal areas of foci and emphasis in regard to the *Standards* document's description of teachers' behaviors (performances) and their continued professional learning. The section concludes by considering concepts such as critical dispositions, defined as "habits" and "commitments" associated with effective teaching (p.6), as emergent features of the teacher's overall identity system.

Does the content of the *Teaching Standards and Learning Progressions* document map onto a complexity approach to teaching and teachers' learning?

The analyses focused first on the Introduction and Summary section of *Standards*. Because this section lays out a prescriptive stance on effective teaching, its statements reflect the assumptions of the standards and learning progressions. Then, to understand how effective teaching develops over time, we examined the learning progressions section of *Standards*. In particular, we were interested in identifying statements that might align with a complex systems perspective on learning and change. In both steps, an inductive approach to category development was used.

Assumptions about the Nature of Effective Teaching.

Table 3 presents three themes that emerged from an inductive analysis of imperatives in the Introduction and Summary sections of *Standards*: contextual adaptability, an iterative approach to improvement of practice, and deliberate self-improvement.

The first theme reflects the imperative of contextual adaptability and emphasizes the role of context in the teachers' learning and practice. The opening section of the document emphasizes that teachers *must* be able to adapt their practices to suit the needs of diverse learners and *must* be able to call upon their content and pedagogical content knowledge in a flexible manner in order to adapt to meet the conditions of the teaching context in which they find themselves. These imperatives are consistent with, but do not presuppose, an ontologically complex perspective on teaching that would position the teacher in a

Table 3

Thematic Analysis of Imperatives in Introduction to the Teaching Standards and Learning Progressions

Theme	Quote
Contextual Adaptability	"teachers **need** knowledge and skills to **customize learning** for learners with a range of individual differences." (p.4) "teachers **need** to recognize that all learners bring to their learning **varying experiences**, abilities, talents, and prior learning, as well as language, culture, and family and community values that are assets that can be used to promote their learning." (p.4) "teachers **must** understand that learning and developmental patterns vary among individuals, that **learners bring unique individual differences** to the learning process, and that learners need supportive and safe learning environments to thrive." (p.8). "teachers **must** have a **deep and flexible understanding** of their content areas and be able to draw upon content knowledge as they work with learners to access information, apply knowledge in real world settings, and address meaningful issues to assure learner mastery of the content." (p.8). "teachers **must** know how to motivate, engage, and inspire their students and do this within a **fluid and organic environment that requires constant awareness and adjustment** across multiple learners and learning modes, and often with limited resources and support." (p.11)
Iterative Approach to Improving Practice	"teachers **must** become more knowledgeable about more effective strategies (know), implement them in a real context (do), gather evidence of learner response to the strategy (use data), reflect upon that evidence (reflect), if possible seek feedback from others like a mentor, coach, peer tutor or observer (get feedback), and then **make adjustments** (adjust) and **repeat the cycle**." (p.11) "The core teaching standards **require** teachers to open their practice to observation and scrutiny (transparency) and **participate in ongoing, embedded professional learning** where teachers engage in collective inquiry to improve practice." (p.5) "Effective instructional practice **requires** that teachers understand and **integrate assessment, planning**, and instructional strategies in coordinated and engaging ways." (p.9) "teachers **need** to know how to **make decisions informed by data** from a range of assessments, including once-a-year state testing, district benchmarks tests several times a year, and ongoing formative and summative assessments at the classroom-level." (p.5) "teachers **need** to have greater knowledge and skill around how to develop a range of assessments, how to balance use of formative and summative assessment, and how to use assessment data to understand each learner's progress, **plan and adjust instruction as needed**, provide feedback to learners, and document learner progress against standards." (p.5)

Theme	Quote
Deliberate Self-Improvement	"teachers **are expected** to **work with and share responsibility** with colleagues, administrators, and school leaders as they work together to improve student learning and teacher working conditions." (p.5)
	"teachers **must** be taught how to work through this cycle and should leave their initial preparation with the skill to **reflect on their practice alone and with others, and evaluate their practices** against a framework of developmental growth." (p.11)
	"teachers **must** have a deeper understanding of their own **frames of reference** (e.g. culture, gender, language, abilities, ways of knowing), the **potential biases** in these frames, and their **impact on expectations** for and relationships with learners and their families." (p.4)
	"teachers **must** engage in meaningful and intensive professional learning and self-renewal by regularly **examining practice through ongoing study, self-reflection, and collaboration**." (p.10)

Note. The statement reflects an imperative and its associated theme.

dynamically responsive, reciprocally influential relationship with the classroom and school context. The imperatives imply that the teacher's internal knowledge and activity system must be coherent but also adaptive and flexibly responsive to, or coupled with, the classroom and its learners. Furthermore, they connect teachers' knowledge of *what* or *how* to teach with strategies for determining the *when* and the *who* of teaching. Such a perspective is supported by the DSMRI, which views the teacher's social context as surrounding and influencing teachers' learning and decision making.

A second, complexity oriented theme is the imperative for teachers to adopt an iterative approach to improving their practice. Here, emphasis is placed on the use of various sources of feedback including peer observations and student assessment data for the purposes of planning and adjusting instruction. From a complex systems perspective, feedback serves as the means by which reciprocal and interdependent relations can impact system components at both individual and collective levels. A related, third imperative is that teachers engage in deliberate self-improvement, using an internal feedback mechanism—the capacity for self-reflection—as a means to do so. This imperative is also congruent with the DSMRI, as it emphasizes that teachers' beliefs, knowledge and attitudes can act as a catalyst for changing actions in the classroom.

Assumptions about the Development of Teacher Expertise

The Learning Progressions section of the *Standards* document often used the term "and..." to denote competencies and performances that should appear at higher levels in addition to lower levels. The number of indicators increased with each level within the learning progressions, which may be an artifact of how the document is constructed.

Nonetheless, terminology used in the *Standards'* Rationale section for the inclusion of learning progressions is broadly amenable to complexity-oriented perspectives on teaching and teacher development. References were made to complexity and non-linearity, iterative processes, and the successive incorporation of prior skills into newly organized, more sophisticated levels of practice (Table 4). According to the document, teachers' expertise may not develop in a linear fashion and elements of teachers' knowledge and skill may come to function in combination with one another in particular situations.

Table 4
Complexity Terms in Learning Progressions Rationale Statement

Relevant term	Quote
Complex	"Learning and teaching are **complex** because they involve humans and relationships." (p.11)
Not Linear	"Teaching expertise can be learned, develops over time, and is **not linear**." (p.11)
Feedback	"Growth can occur through reflection upon experience, **feedback**, or individual or group professional learning experiences." (p.11)
Context	"Development depends on **context**, particularly levels of support." (p.11)
Reciprocal Iterative	"The teacher has a **reciprocal** and **iterative** relationship with context that needs to be taken into account when supporting their growth and development." (p.12)
Shift	"In the design of the progressions section, these are called "**shifts**" in knowledge and skill between levels and include illustrative examples of professional learning that would promote growth toward the shift." (p.13)
Fluid	"The progressions text is listed in columns with permeable lines between them to denote the **fluid** nature of development" (p.14)
Additive	"The developmental levels are **additive**…while there are significant shifts in practice, some parts of prior performance also come forward as appropriate to the work of teaching." (p.14)
Synthesis	"As teaching becomes more **complex**, elements function in combination or **synthesis**." (p.14).

Indicators of acceptable professional learning reflected varying teacher agency—the presence or absence of deliberate, volitional, goal-oriented actions in specific situations and contexts (Priestley, et al., 2015). Moreover, the content analysis revealed language indicative of varying expectations for the scope of the context for teachers' actions. Some expectations pertain to the immediate context, such as the classroom, and others pertain to a variety of broad contexts such as the school, the community, and the profession. Statements were coded for both agency and context: for example, indicators reflecting low

agency and an immediate context could pertain to the teacher receiving assistance in defining learners' needs, whereas indicators reflecting low agency and a broad context could include teachers' completion of mandated professional learning requirements. High agency, immediate context indicators included teachers being prepared to self-select instructional roles that best suited the current situation, and high agency, broad context indicators included collaborating with colleagues within the school to give, receive, and analyze feedback to improve outcomes for specific individuals or groups.

Overall expectations for teacher agency and context vary by learning progression. Of the agency elements, 15% refer to low agency activities and are situated in learning progression Stage 1, but only 7% are found in Stage 2 and 1% of the elements were found in Stage 3. This contrasts with a more consistent pattern across stages for high agency activities; 17% of agency elements refer to high agency activities and are included in Stage 1, 25% are included in Stage 2, and 32% in Stage 3. Two thirds of the indicators placed more emphasis on the teachers' immediate classroom context than the broader school, community or professional context. The ratio of indicators pertaining to the immediate versus a broad context was found to be approximately 6 to 1 for learning progression 1, approximately 2 to 1 for learning progression 2, and almost 1 to 1 for learning progression 3. In sum, as teachers progress in their maturity and expertise, *Standards* clearly lays out an increase in the scope of teachers' impact and shifting expectations regarding their agentic actions to continue learning. These shifts are portrayed visually in the contour diagram in Figure 2.
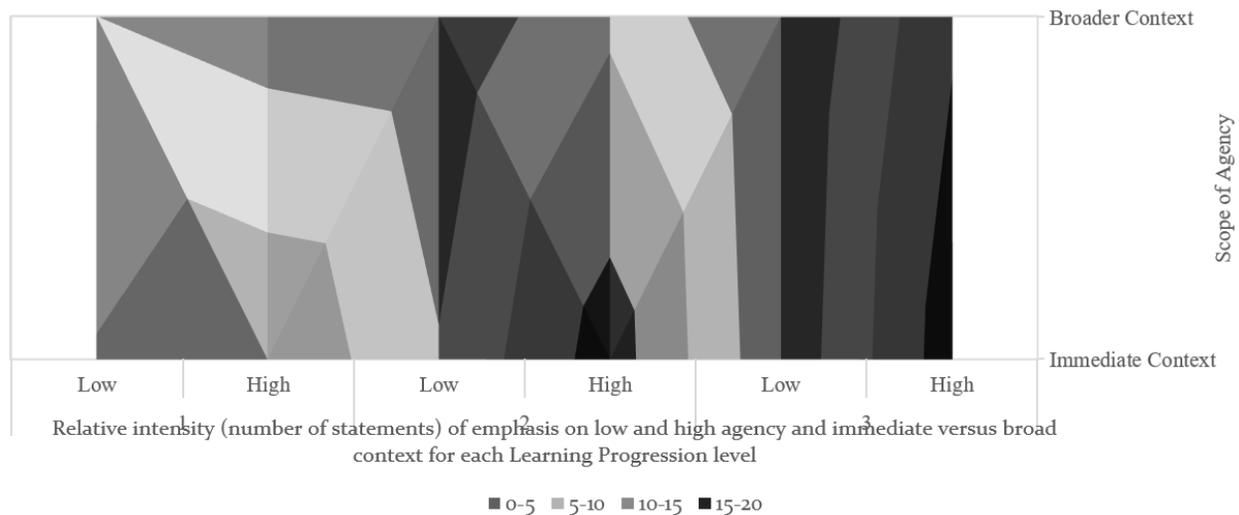

Figure 2. Frequency-Based Landscape of Teacher Agency for each Learning Progression Level

How might a complex systems approach to teachers' learning and change augment understanding of the *Teaching Standards and Learning Progressions*?

We approached this question using general complex systems concepts as well as one complex systems-informed theory that has been applied empirically to the study of teacher learning, motivation, and professional role identity. Our approach was separated into the conceptualization of teachers' demonstrable actions or performances as a complex system within a behavioral landscape in which particular actions might be more or less likely to occur, and a theoretically guided question about how teachers' professional learning might be theorized using the DSMRI in particular.

A Behavioral Landscape for Teachers' Performances

An inductive analysis of the *Performances* reveals three factors that are present or absent in different combinations: the learner, and/or the content and/or the context of teaching. Performances were coded according to whether they emphasized each of these dimensions. These are represented using a three dimensional interpretive graphic in Figure 3.

All of the Performances refer to behavioral foci of either the content, the learner, and/or the context. Nearly half (49%) of the performances refer to the teacher's actions being in service of the learner in some way. In complex systems terms, meeting the learner's needs presents a significant attractor for the teacher's learning and action. For example, Standard 1: Learner Development Performance 1(b), includes reference to the learner (but not to the content): "The teacher creates developmentally appropriate instruction that takes into account individual learners' strengths, interest, and needs and that enable each learner to advance and accelerate his/her learning" (p.16). However, Standard 4: Content Knowledge Performance 4 (h), refers to learner *and* content: "The teacher creates opportunities for students to learn, practice, and master academic language in their content" (*Standards,* p.24). Just over one quarter (27%) of the performances refer to the learner and the context, but not the content. For example, Standard 3: Learning Environments Performance 3(e), emphasizes learner *and* context by way of "The teacher manages the learning environment to actively and equitably engage learners by organizing, allocating, and coordinating the resources of time, space, and learners' attention" (*Standards,* p.21). A very small proportion (3%) of the Performances explicitly refer to learner, content and context, such as Standard 5: Application of Content Performance 5(c), "The teacher facilitates learners' use of current tools and resources to maximize content learning in varied contexts" (p.27). In aggregate, this analysis reveals an "ideal" behavioral landscape that, according to *Standards,* prioritizes behaviors in which the teacher

demonstrates the ability to integrate learner variables with either content-related considerations or contextual factors, but not all three parameters of learner, content, and context). The figure reveals the relative emphasis on the learner, within and separately from context, and separately from as well as in relation to the subject matter.
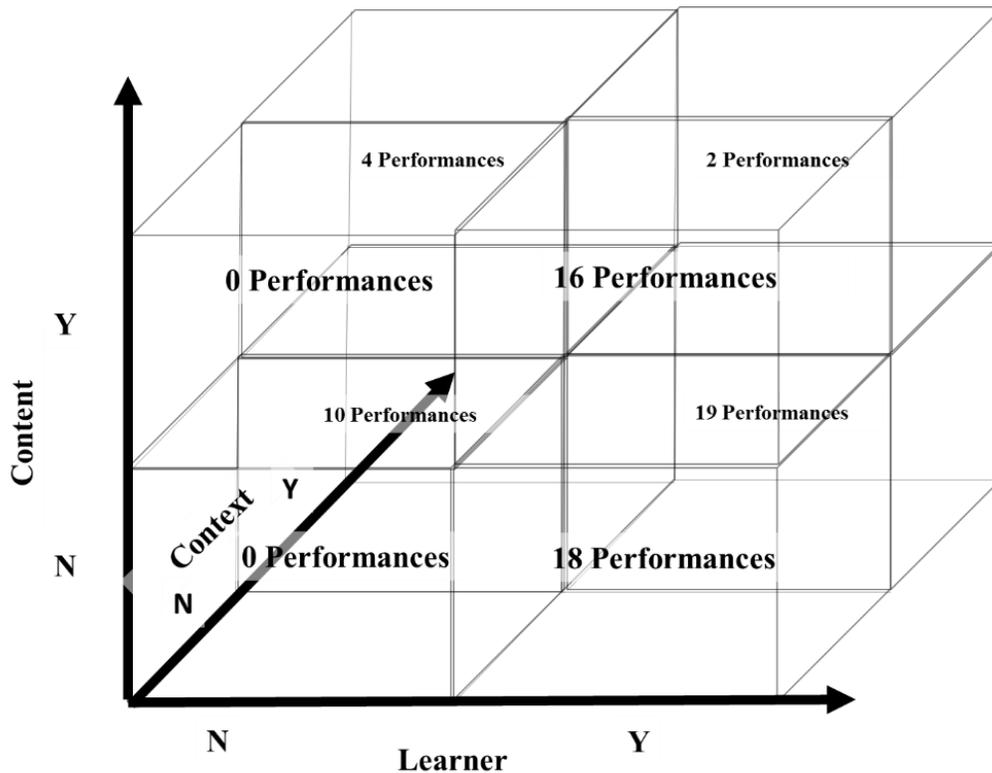

Figure 3. Three-Dimensional Representation of Learner Emphasis, Subject Matter (Content), and Learning Environment (Context) as Behavioral Foci of Teachers' Performances

A Behavioral Landscape for Teachers' Learning

The previous analysis resulted in a landscape for teachers' performances but did not attend to how the landscape might shift as a teacher learns. To investigate mechanisms of teacher learning within the *Standards* and how the attractors within the behavioral landscape may shift as teachers develop expertise, we examined each of the standards for indicators of how teachers are expected to learn. Descriptions of professional learning activities referred to efforts that were either individual or collaborative in nature, in service of reaching either immediate (classroom-focused) or broad (school or community-focused) contexts. The aggregate variations of individual versus collective and immediate versus

broad context are shown for each teaching standard in the contour diagram in Figure 4. The dark grey horizontal band across the middle represents a higher frequency of indicators in a particular category and shows that teachers' professional learning experiences are often expected to be undertaken either individually in service of a broad context, or collaboratively in service of an immediate context.
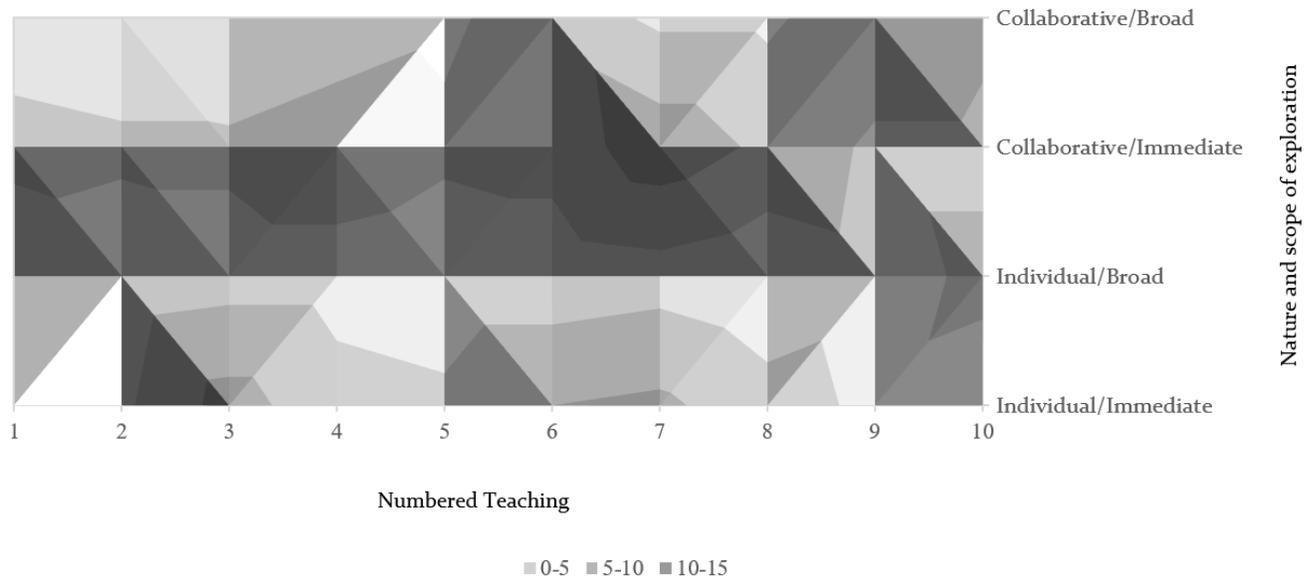

Figure 4. Frequency-Based Landscape of the Nature of Exploration by Teaching Standard

Some exceptions exist, such as Standard 2: Learning Differences, in which teachers' learning is emphasized as individual in nature and in service of the immediate classroom context, and Standard 6: Assessment, in which teachers' learning is expected to be undertaken collaboratively in service of the broader school context. This reveals assumptions about the nature of the teacher; in Standard 2, the emphasis is on teachers' individual learning in order to serve the different needs of his or her own students, and this carries an assumption that more individual learning activities are effective in developing teachers' cultural, linguistic, and instructional competence. In Standard 6, however, the emphasis on learning about assessment encourages teacher to work together to gather multiple sources of evidence for students' learning gains, and share these insights across the broader context of the school.

Critical Dispositions as Emergent Identity Phenomena
Within *Standards,* 'critical dispositions' refers to enduring "habits of professional action" and "moral commitments" by the teacher (p.6). Within the DSMRI, the term

dispositions is used to indicate a cultural control parameter of meanings that integrate the psychological characteristics of each teacher and frame each one's individual teacher role identity system. Therefore, in the specific DSMRI-informed analysis we focused on the ways in which the critical dispositions included in *Standards* might align with and emerge from competencies and underlying cognitive structures and processes included as role identity components—self-perceptions, goals, beliefs, and action possibilities in the role of teacher. The analysis is exemplified in Table 5, where annotations are included to illustrate how the definitions of each standard aligns with these components. Each definition shown in Table 5 reflects a fundamental tenet of the DSMRI—that action arises to serve goals in light of particular beliefs about the world and in accordance with perceptions and definitions of oneself—and provides multiple examples of the ways in which teachers' actions are emergent from the interactions between their beliefs about and goals for teaching and learning. Notably, the standards did not explicitly refer to ideal self-perceptions of a teacher whose beliefs and goals might give rise to the actions described within them. This analysis reveals an important pathway for future research into how such actions develop in accordance with this important facet of teacher identity.

For most of the standards, role identity components are revealed through alignments between teachers' beliefs and goals for their teaching and action possibilities that allow for the enactment of performances and bring these goals to fruition. For example, under Standard 2: Learning Differences, a logical link is explicated between the teacher's action possibility that aims at the goal to create "inclusive learning environments that enable each learner to meet high standards" (p.8) and the neighboring statement that emphsizes knowledge and beliefs about "individual differences and diverse cultures and communities" to frame pursuit of this goal. Similarly, under Standard 8: Instructional Strategies, the standards emphasize that teachers should employ the action possibility of using "a variety of instructional strategies" in service of the goal of encouraging "learners to develop deep understanding of content areas and their connections" (p.9).

Table 5

Teacher Identity System Components in the Definitions of the Teaching Standards

Category	Standard	Definition
The Learner and Learning	1. Learner Development	The teacher understands how learners grow and develop, [**BA: recognizing that patterns of learning and development vary individually within and across the cognitive, linguistic, social, emotional, and physical areas**], and [**AP: designs and implements developmentally appropriate and challenging learning experiences**].

Category	Standard	Definition
	2. Learning Differences	The teacher uses [**BA: understanding of individual differences and diverse cultures and communities**] [**PG: to ensure inclusive learning environments that enable each learner to meet high standards**].
	3. Learning Environments	The teacher [**AP: works with others**] [**PG: to create environments that support individual and collaborative learning, and that encourage positive social interaction, active engagement in learning, and self-motivation**].
Content Knowledge	4. Content Knowledge	The teacher understands the central concepts, tools of inquiry, and structures of the discipline(s) he or she teaches and [**AP: creates learning experiences that make these aspects of the discipline accessible and meaningful for learners**] [**PG to assure mastery of the content**].
	5. Application of Content	The teacher understands [**AP: how to connect concepts and use differing perspectives**] [**PG: to engage learners in critical thinking, creativity, and collaborative problem solving related to authentic local and global issues**].
Instructional Practice	6. Assessment	The teacher understands and [**AP: uses multiple methods of assessment**] [**PG: to engage learners in their own growth, to monitor learner progress, and to guide the teacher's and learner's decision making**].
	7. Planning for Instruction	The teacher [**PG: plans instruction that supports every student in meeting rigorous learning goals**] by [**AP: drawing upon knowledge of content areas, curriculum, cross-disciplinary skills, and pedagogy, as well as knowledge of learners and the community context**].
	8. Instructional Strategies	The teacher understands and [**AP: uses a variety of instructional strategies**] [**PG: to encourage learners to develop deep understanding of content areas and their connections, and to build skills to apply knowledge in meaningful ways**].
Professional Responsibility	9. Professional Learning and Ethical Practice	The teacher [**AP: engages in ongoing professional learning and uses evidence**] [**PG: to continually evaluate his/her practice**], particularly the effects of his/her choices and actions on others (learners, families, other professionals, and the community) and [**AP: adapts practice**] [**PG: to meet the needs of the learner**].
	10. Leadership and Collaboration	The teacher [**AP: seeks appropriate leadership roles and opportunities**] to [**PG: take responsibility for student learning**], [**AP: to collaborate with learners, families, colleagues, other school professionals, and community members**] [**PG: to ensure learner growth, and to advance the profession**].

Key. AP: Action Possibilities; PG: Purpose and Goals; BA: Beliefs and Assumptions

Finally, the DSMRI proposes that processes of identity exploration and commitment (Marcia, 1966; Tao & Gao, 2017) underpin the emergence of new (or new alignments and tensions among) beliefs, goals, action possibilities, and self-perceptions (Kaplan & Garner, 2017). Identity processes and outcomes of exploration and commitment development were referred to in the Critical Dispositions portion of most of the standards. These are indicated in Table 6, which also lists other Dispositions that were coded as embodying self-perceptions (to include self-definitions such as ascribed values), goals, beliefs, and their development through a process of exploration. The most common identity process included in the critical dispositions section was the development of commitments, which was mentioned 20 times. These references varied from commitments to use knowledge of learners' strengths (beliefs) to further each student's development (goal) to a commitment to the ethical use of assessment data (self-perceptions and action possibilities) to identify these strengths (goal). Explicit, common identity outcomes or emergent identity states included values (self-perceptions), which were included 11 times. *Standards* calls for teachers to possess various values, for example the valuing of diverse languages in instructional practices or valuing planning as a collegial and collective activity. In doing so, *Standards* clearly connect teachers' identity components and processes to the concept of teachers' professional learning.

Table 6

DSMRI Informed Coding of Critical Dispositions

	Standard	Critical Disposition	DSMRI code
1.	Learner Development	The teacher respects learners' different strengths and needs and is committed to using this information to further each learner's development.	Commitment
		The teacher is committed to using learners' strengths as a basis for growth, and their misconceptions as opportunities for learning.	Commitment
		The teacher takes responsibility for promoting learners' growth and development	Commitment
		The teacher values the input and contributions of families, colleagues, and other professionals in understanding and supporting each learner's development.	Value
2.	Learning Differences	The teacher believes that all learners can achieve at high levels and persists in helping each learner reach his/her full potential.	Belief
		The teacher respects learners as individuals with differing personal and family backgrounds and various skills, abilities, perspectives, talents, and interests.	Belief

Standard	Critical Disposition	DSMRI code
	The teacher makes learners feel valued and helps them learn to value each other.	Value
	The teacher values diverse languages and dialects and seeks to integrate them into his/her instructional practice to engage students in learning.	Value
3. Learning Environments	The teacher is committed to working with learners, colleagues, families, and communities to establish positive and supportive learning environments.	Commitment
	The teacher values the role of learners in promoting each other's learning and recognizes the importance of peer relationships in establishing a climate of learning.	Value
	The teacher is committed to supporting learners as they participate in decision-making, engage in exploration and invention, work collaboratively and independently, and engage in purposeful learning.	Commitment
	The teacher seeks to foster respectful communication among all members of the learning community.	Goal
	The teacher is a thoughtful and responsive listener and observer.	Self-Perception
4. Content Knowledge	The teacher realizes that content knowledge is not a fixed body of facts but is complex, culturally situated, and ever evolving. S/he keeps abreast of new ideas and understandings in the field.	Assumption
	The teacher appreciates multiple perspectives within the discipline and facilitates learners' critical analysis of these perspectives.	Value
	The teacher recognizes the potential bias in his/her representation of the discipline and seeks to appropriately address problems of bias.	Assumption
	The teacher is committed to work towards each learner's mastery of disciplinary content and skills.	Commitment
5. Application of Content	The teacher is constantly exploring how to use disciplinary knowledge as a lens to address local and global issues	Exploration
	The teacher values knowledge outside his/her own content area and how such knowledge enhances student learning.	Value
	The teacher values flexible learning environments that encourage learner exploration, discovery, and expression across content areas.	Value
6. Assessment	The teacher is committed to engaging learners actively in assessment processes and to developing each learner's capacity to review and communicate about their own progress and learning.	Commitment
	The teacher takes responsibility for aligning instruction and assessment with learning goals.	Commitment

	Standard	Critical Disposition	DSMRI code
		The teacher is committed to providing timely and effective descriptive feedback to learners on their progress.	Commitment
		The teacher is committed to making accommodations in assessments and testing conditions, especially for learners with disabilities and language learning needs.	Commitment
		The teacher is committed to the ethical use of various assessments and assessment data to identify learner strengths and needs to promote learner growth.	Commitment
7.	Planning for Instruction	The teacher respects learners' diverse strengths and needs and is committed to using this information to plan effective instruction.	Commitment
		The teacher values planning as a collegial activity that takes into consideration the input of learners, colleagues, families, and the larger community.	Value
		The teacher takes professional responsibility to use short- and long-term planning as a means of assuring student learning.	Commitment
		The teacher believes that plans must always be open to adjustment and revision based on learner needs and changing circumstances.	Belief
8.	Instructional Strategies	The teacher is committed to deepening awareness and understanding the strengths and needs of diverse learners when planning and adjusting instruction.	Commitment
		The teacher values the variety of ways people communicate and encourages learners to develop and use multiple forms of communication.	Value
		The teacher is committed to exploring how the use of new and emerging technologies can support and promote student learning.	Commitment
		The teacher values flexibility and reciprocity in the teaching process as necessary for adapting instruction to learner responses, ideas, and needs.	Value
9.	Professional Learning and Ethical Practice	The teacher takes responsibility for student learning and uses ongoing analysis and reflection to improve planning and practice.	Commitment
		The teacher is committed to deepening understanding of his/her own frame of reference...the potential biases in these frames, and their impact on expectations for and relationships with learners and their families.	Commitment
		The teacher sees him/herself as a learner, continuously seeking opportunities to draw upon current education policy and research as sources of analysis and reflection to improve practice.	Self-Perception

Standard	Critical Disposition	DSMRI code
	The teacher understands the expectations of the profession including codes of ethics, professional standards of practice, and relevant law and policy.	Commitment
10. Leadership and Collaboration	The teacher actively shares responsibility for shaping and supporting the mission of his/her school as one of advocacy for learners and accountability for their success.	Commitment
	The teacher respects families' beliefs, norms, and expectations and seeks to work collaboratively with learners and families in setting and meeting challenging goals.	Value
	The teacher takes initiative to grow and develop with colleagues through interactions that enhance practice and support student learning.	Self-Perception
	The teacher takes responsibility for contributing to and advancing the profession.	Commitment
	The teacher embraces the challenge of continuous improvement and change.	Commitment

DISCUSSION

Our analysis of the *Standards* explored the congruence between a policy document that reflects a consensual perspective among educational researchers, practitioners, and policymakers on the nature of teaching and teacher learning, and a contemporary perspective on teaching that draws from complex dynamic systems theory. We laid the foundation for conceptualizing the phenomena as a complex system, by identifying imperatives that act as constraints or control parameters for effective teaching, and behavioral targets that reveal the landscape of the teacher identity system and its actions (Juarrero, n.d.; Kunnen & van Geert, 2012; Stanton & Welsh, 2012). Along the way, we uncovered an emphasis on desirable qualities of effective teachers that resonate with a complex systems perspective, such as cyclical learning and change, adaptation and flexibility in response to context, and overall patterns of emphasis on various types and outcomes of teachers' learning activities. Although the document does not explicitly discuss the interplay among the different standards, our analyses of the different standards areas revealed common mechanisms by which teachers might develop. The interrelations among the standards and the ways in which teachers' learning and skill development in one area influences one or more other areas may be interesting avenues for future research.

We now expand on these findings to more generally consider the implications of a complex systems perspective as it applies to the *Standards* policy document. We anchor

our discussion using specific terminology that considers reciprocal interactions among nested elements, self-organization and its relevance for systems that display sensitivity to initial conditions, and deliberate exploration as a critical component of new learning. Then, drawing these teacher learning and performance concepts together under a broad framework of teacher identity using the DSMRI, we conclude with implications for collaboration among researchers, practitioners and policymakers.

Reciprocal Influences Among Nested Elements

  Standards lists four directed categories for teachers' professional skills—the learner and learning, content knowledge, instructional practice, and professional responsibility—and includes expected performances and behavioral indicators for each one. However, the document does not refer to the ways in which these might develop in parallel or influence one another. If these areas of professional skill are thought to co-exist within the teacher, a complex systems perspective would anticipate reciprocal influences among them such that changes in one area would stabilize or destabilize one or more others. For example, in an instrumental case study Garner and Kaplan (2019) found that changes in a science teachers' experiences of particular instructional strategies triggered changes in beliefs about learners' needs and developments in the teacher's assumptions about the nature of students' learning. In a multiple case study, Hathcock, et al. (2020) found that teachers' prior beliefs about the nature of individual and collaborative learning in professional development settings influenced their capacity to imagine using the modeled instructional strategies as action possibilities for their own classrooms. In other words, teachers' constructions of what professional learning is and how it takes place was very much connected to how much they changed in regard to serving the learner and preparing to teach the content.

  Elements that have reciprocal influences on one another exist within a nested system of systems, and interactions among elements can occur within and across systems (Hilpert & Marchand, 2018). One prominent finding from our analysis of the learning progressions was the emergence of the context as an important focus for teachers' actions, where immediate contexts included the classroom and broad contexts refer to the school and its wider community. The *Standards* document does not address the ways in which these two types of contexts might influence one another but using a complex systems perspective we might consider them to be nested systems, and therefore consider how actions or skills in contexts of one scope might impact those in another. For example, Standard 10, which focuses on leadership and collaboration, encourages teachers to engage in broad context collaboration with families, colleagues and members of the community for the benefit of learners within the immediate context of their classroom. Once again, future research might examine the ways in which teachers develop various skills that

impact immediate and broad contexts, and how these contexts in turn support or inhibit teachers' learning.

Self-Organization and Sensitivity to Initial Conditions

Complex adaptive systems include elements that are sensitive to information in the environment and interact in ways that increase congruence between the system and its environment. This means that the system is sensitive to changes in environmental or contextual conditions (Gell-Mann, 1994) and that the emergent interplay among the system and its context leads to changes in system behavior. Perhaps the closest parallel to this idea is Opfer and Pedder's (2011) notion of the teachers' learning activity system, from which it is proposed that changes in knowledge, beliefs and practices emerge through the interaction between the individual teacher and their contexts for professional learning and practice. When a complex adaptive systems perspective is overlaid on the otherwise serial and additive list of indicators included in the learning progressions, two key implications arise. The first is that because the teacher's systems seek to re-establish coherence and stability following a perturbation or experience of dissonance, the outcome of a change-inducing event may not be a more sophisticated form of practice *unless it is accompanied by environmental support.* Second, as Opfer and Pedder (2011) point out, professional development "features may collectively work together in different ways under different circumstances in different contexts" (p.386). In essence, teaching remains closely tied to particular, emergent configurations of the teacher and their context, and may be sufficiently sensitive to such configurations as to amplify or suppress change. The *Standards* offers specific indicators that may allow researchers and practitioners to examine the emergence of these changes over time, in response to particular forms of professional development, and in light of particular contextual conditions. However, the document does not offer insight into how professional development might address multiple standards or indicators, and so once again this might be a fruitful area for future research.

Deliberate Exploration and Teachers' Learning

Newell and colleagues (Newell et al. 1991) propose that, when modeling individuals' behavior as a complex system, learning and expertise development arises from deliberate explorations around the conceptual landscape, or workspace. This idea combines the notion of the teacher as an adaptive system but also emphasizes the role of individual agency in promoting increasingly sophisticated practice. Newell views the learner as an active participant in their own learning experiences; this is echoed in the literature on teacher professional development that promotes learning and change (Guskey, 2002), and is somewhat reflected in the high agency learning activities included throughout the *Standards.*

The analysis of the learning progressions revealed increasing expectations for teacher agency from level 1 to level 3 (see Table 2). In addition, the focal target of teachers' learning and exploration was found to shift from a primary emphasis on the immediate context to a dual emphasis on immediate and broad contexts. Exploration as a mechanism for learning was mostly described as an individual endeavor, although collaborative exploration was encouraged for Standard 6: Assessment, Standard 9: Professional Learning and Ethical Practice, and Standard 10: Leadership and Collaboration. Given the consensus finding in the literature that teachers experience meaningful learning when they participate in professional learning communities or other professional social contexts (Birman, Desimone, Garet & Porter, 2000), our finding raises questions about how administrators and teacher educators might align the types of professional learning activities encouraged in *Standards* with common professional development formats such as face-to-face and virtual learning communities, summer institutes, and workshops.

Identity as an Overarching Framework for the Maturation of Teaching

The summary definitions for each standard (Tables 1 and 5) reflect consensus in the teacher education and professional learning literature about the role of identity components of teachers' knowledge and beliefs, self-perceptions, goals, and possibilities for action, in producing sophisticated, high quality teaching. The DSMRI informed analysis revealed ways in which these components can be configured according to a complex systems perspective. The *Standards* definitions also revealed the position of the Committee in regard to the relations among these identity components. Teachers were assumed to hold particular goals for their teaching, for example engaging learners in their own growth, and to do so with particular action possibilities such as using multiple methods of assessment. The contents of these statements provide identity scholars, professional development designers, and teachers with an excellent source of material to which teachers' existing identity configurations can be compared. In addition, the critical dispositions included for each standard area also provide information about the goal of the Committee in producing collective system convergence among multiple teachers' identities, in the form of shared values, beliefs, and commitments (Table 6).

Yet, a need remains to more explicitly integrate complex systems informed approaches to teacher identity and learning with a policy document outlining mature manifestations of high-quality teaching. Further research is needed to examine how, through which experiences, and under which contexts teachers' identity systems develop, how this leads to the emergence of expertise over time, and the ways in which the contents of each standard influence one another in diverse settings and over the course of teachers' careers. Complex systems approaches including the DSMRI may prove to be fruitful in their deliberate attention to the nested system of the teacher in their sociocultural and personal

context, and may therefore provide a framework for examining the relations among the teacher, school, and activity systems (Opfer & Pedder, 2011).

CONCLUSION

The *Standards* document lays out a clear vision for high-quality teaching and emphasizes ten areas of competence that develop over three stages or learning progressions. The document proposes that mature teaching manifests adaptability, and iterative, deliberate attempts at improvement across domains that focus on the learner and learning, content, instructional practice, and professional responsibility. Performance indicators of high-quality teaching most often involve the teacher addressing the learner in relation to content or the learner in relation to context, with less attention paid to the teachers' integration of all three. The teacher learns over time with increasing agency, which reflects varying scopes of impact, and consistent, goal-directed volition.

Standards implicitly characterizes effective teaching as an ontologically dynamic construct. In doing so, it shares tenets with situative and systems approaches, and provides researchers, practitioners and policymakers with an entry point for considering complex systems perspectives as they investigate, design for, and evaluate teaching and teachers' learning. Since systems perspectives align well with multidisciplinary, partnership-based teacher professional development initiatives, *Standards* may lead to explicit discussions of how each stakeholder group approaches the question of high-quality teaching. *Standards* can guide conversations among research-practice partners and serve as a tool for assessing areas of need as well as a barometer of change in response to an intervening or emerging perturbation to one or more levels of the nested system of the teacher-in-context. Our complexity informed lens towards *Standards* offers a framework for describing and measuring teacher-level and school-level problems of practice that often serve as the starting point for researcher-practitioner partnerships and design-based classroom research (Anderson & Shattuck, 2012). In time, partnerships among practitioners, researchers and policymakers may draw on, and contribute to, complex systems interpretations of the *Standards* document and other, similar guidance documents. Such efforts will bring new understandings of the multiple, nested and reciprocal systems that influence teachers' learning and practice.

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