

To cite this article: James R. Brawn (2026). APPLYING DYNAMIC SYSTEM THEORY TO TEACHER BELIEFS, TEACHER KNOWLEDGE, AND TEACHER COGNITION, International Journal of Education and Social Science Research (IJESSR) 9 (3): 01-10 Article No. 1241, Sub Id 1913

APPLYING DYNAMIC SYSTEM THEORY TO TEACHER BELIEFS, TEACHER KNOWLEDGE, AND TEACHER COGNITION

James R. Brawn

Hankuk University of Foreign Studies, Dept. of English Language Education,
107 Imun-ro, Dongdaemun-gu, Seoul, South Korea
jbrawn67@gmail.com

DOI : <https://doi.org/10.37500/IJESSR.2026.9315>

ABSTRACT

Current research has noted that teacher beliefs, knowledge, and cognition are closely interrelated constructs that collectively influence teaching practices. Moreover, research on teacher beliefs, knowledge, and cognition should be situated and studied in terms of development processes, that is, processes of dynamic systems and change. This is because these processes are experiential and involve maturation through reflection on practice and an awareness of the ever-changing needs of the students in the teacher's care. As with any developmental process, teacher development occurs over time in a nonlinear manner, with as many steps back as forward. Dynamic systems theory (DST) offers a framework for understanding how teachers' knowledge, beliefs, and practices interact with one another and the environment in which they work, producing change over time. This paper will explore methodological considerations for applying dynamic systems theory within a complex systems approach to studying teacher beliefs, knowledge, and cognition, and provide relevant examples from the research.

KEYWORDS: teacher cognition, teacher beliefs, teacher knowledge, dynamic systems theory.

1. INTRODUCTION

When researching teacher development, a Dynamic Systems Theory (DST) perspective is appropriate because it encompasses changes in teacher beliefs, knowledge, and cognition. This multimodal development necessitates methodological approaches that capture the complexity, non-linearity, and interdependence of these evolving constructs within educational contexts. A widely accepted notion is that an intricate relationship exists among a teacher's beliefs, knowledge, and thinking processes. For example, Borg [1]–[3] uses “teacher cognition” as a general or umbrella term that describes the unseen dimensions of teachers' work, encompassing everything teachers think, know, and believe. Moreover, according to Borg [1], teacher cognition, what teachers think, know, and believe, forms the bedrock of effective teaching practices. These constructs are intertwined and are pivotal to professional growth and development. Moreover, understanding how these constructs interrelate and influence each other is essential for teacher development and education. To illustrate how this can affect teacher

development and educations is the questions: Are a teacher's beliefs a lens through which a practitioner interprets and applies knowledge, or are beliefs tacit, so they only inform a practitioner's thought processes and behaviors subconsciously [4], or are beliefs more conscious and explicit and so influence a teacher's approach to teaching and interactions with students more directly [5], or do beliefs and how they interact with others aspects of a practitioner's thought processes and behavior change and develop over time?

To answer these questions, research must be conducted using an approach that can explain complex phenomena resulting from interactions between multiple elements within a system. The approach should also emphasize the roles of context, nonlinearity, self-organization, and adaptation, as teaching and the decisions teachers make to implement the learning process evolve within a dynamic system over time. The approach recommended in this paper is known as Dynamic Systems Theory (DST). When applied to teacher development and teacher cognition, DST provides a framework particularly useful for studying complex, dynamic processes, such as the development of teaching skills and the cognitive processes underlying teaching.

2. Three Seminal Papers on Teacher Beliefs, Knowledge, and Cognition

Over the last 40 years, extensive research has been done on teacher beliefs, knowledge, and cognition. Although the earliest research did not explicitly use DST, since DST did not gain prominence until the early 1990s, many of these projects anticipated key features of DST.

One of those anticipatory studies was conducted by Nespor [6]. In that study, he acknowledged the dynamic and interactive nature of teaching. He underscored that teachers' beliefs are not static but are continually shaped and reshaped through their ongoing experiences and reflections on practice. This nonlinear process of shaping and reshaping is a key tenet of DST. Development is seen as an iterative process because teachers' beliefs are constantly tested by classroom situations and refined or reformulated through reflection. Thus, it posits that systems, in this case, the teacher's cognitive system, are complex, dynamic, and interconnected. It recognizes that development is a non-linear process with feedback loops, and that small changes in one part of the system can cascade through the system. Nespor's emphasis on the interplay between beliefs and practices aligns with the DST notion that the various components of a system (beliefs, knowledge, practices) are interconnected and influence one another over time.

While Nespor's [6] paper does not explicitly anticipate Dynamic Systems Theory (DST), as DST didn't gain prominence, especially in education, until the late 1990s, some of the ideas presented in Nespor's work align with DST principles. For example, DST posits that human behavior and cognition arise from complex, nonlinear interactions within dynamic systems, in which multiple factors continuously influence one another. Nespor [6], in line with DST, acknowledges that teachers' beliefs are evolving, episodic, and context-dependent structures. This aligns with the Dynamic System Theory's view that cognitive and behavioral patterns are emergent and contextually driven. The study's emphasis on the

fluid and often unpredictable nature of belief systems, which adapt to personal and professional experiences, mirrors DST's focus on systems' continuous, dynamic adaptation over time. Additionally, the notion of teaching as an "ill-structured" (p. 324) and "entangled domain" (p. 324) that requires adaptive and flexible problem-solving strategies is a key concept in DST, highlighting the interconnectedness and co-evolution of cognitive, emotional, and contextual factors in shaping teachers' practices.

Shulman [7] was another early researcher on teacher knowledge and beliefs who recognized the bound nature of the two concepts. In his model of teacher knowledge, he recognized that knowledge and beliefs often form a mix of ideas in the practitioner's mind. He argued that teacher knowledge is a complex amalgam of content knowledge, pedagogical knowledge, and curricular knowledge, which takes the specialized form he calls "pedagogical content knowledge" (PCK). Shulman describes pedagogical content knowledge as "uniquely the province" (p. 8) of individual teachers, representing their "special form of professional understanding" (p. 8). Since this amalgam binds beliefs with knowledge, he argued that teachers' beliefs about teaching and learning are essential to their professional knowledge. Moreover, the study highlights the complexity of teaching, where knowledge is dynamic and shaped by both experience and reflection. The paper also critiques previous models of teacher competence for neglecting the cognitive and knowledge-based dimensions of teaching. Importantly, Shulman proposes that effective teaching involves transforming subject-matter knowledge into pedagogically appropriate representations, thereby making content accessible to students.

Like Nespor's [6] paper, Shulman's [7] work also anticipates DST in several ways. First, his conceptualization of teacher knowledge as evolving and contextually embedded aligns with DST's emphasis on the dynamic, adaptive nature of cognition. His identification of pedagogical content knowledge as an emergent, interactive construct mirrors DST's principle that complex systems arise from the interplay of multiple components. Additionally, Shulman's recognition of teacher learning as a recursive process shaped by reflection, experience, and adaptation resonates with DST's focus on feedback loops and non-linearity in development.

A third study that anticipates DST is Pajares [8], which explores the significance of teacher beliefs in educational research and highlights the difficulties in defining and studying them. The paper argues that beliefs are central to understanding teacher decision-making and behavior. Pajares claims that beliefs are often stronger predictors of a teacher's classroom behavior than knowledge. Pajares identifies several key characteristics of beliefs, including their affective and evaluative nature, episodic memory storage, and resistance to change. He also critiques the inconsistency in how researchers have defined and measured beliefs. In the paper, he recommends that researchers provide more precise conceptualizations and better definitions of the constructs. Finally, the study emphasizes that beliefs are often acquired early, shaped by personal experiences, and serve as filters through which new knowledge is interpreted. Because beliefs can persist even in the face of contradictory evidence, they

significantly influence how teachers engage with professional development and instructional practices

Like the other articles described above, Pajares' [8] work anticipates DST by highlighting its complex, interconnected, and evolving nature. DST posits that cognitive and behavioral processes emerge from the dynamic interaction of multiple factors over time. Similarly, Pajares describes beliefs as entangled domains that do not follow simple cause-and-effect relationships but develop through nonlinear interactions with personal experiences and social contexts. His argument that beliefs act as self-reinforcing systems resistant to change aligns with DST's emphasis on stability and attractor states in dynamic systems. Furthermore, Pajares' notion that beliefs shape the interpretation and structuring of new information parallels DST's view that cognition continuously adapts through feedback loops.

3. Dynamic Systems Theory (DST)

The principles and propositions that underlie DST are not entirely new. They are, however, a modern extension of earlier systems theories rooted in biology, psychology, and even physics. In terms of development, there are two central themes: "1) Development can only be understood as the multiple, mutual, and continuous interaction of all the levels of the developing system, from the molecular to the cultural [and] 2) Development can only be understood as nested processes that unfold over many timescales from milliseconds to years" (p. 258) [9]. Thus, DST should be considered as both a metatheory, that is, a conceptual lens applicable across disciplines, and a specific theoretical model for understanding the processes of change and maturation in development.

Historically, the impetus for applying DST to cognitive development has come from its use in embryonic studies. These studies needed to explain how complex patterns emerge from simpler initial conditions without any causal agent overseeing or directing that development. This means that "patterns and order emerge from the interactions of the components of a complex system without explicit instructions either in the organism itself or from the environment" (p. 259) [9]. Consequently, the principle of self-organization, the idea that complex order arises through interaction rather than centralized control, is foundational to DST.

Another important implication when applying DST to the study of cognitive development is the recognition that development is not always linear. Development and learning have traditionally been described as linear processes in which the individual or organism progresses through earlier stages before reaching a higher stage. However, this is not true. Development does not proceed in a neat, straight, or predictable line. Developmental progress often involves periods of expansion followed by periods of constriction; that is, an individual may temporarily regress or show variability before achieving stability.

Consequently, when applying DST timescales to teacher cognition, researchers need to consider that development occurs from moment to moment, from lesson to lesson, from semester to semester, and finally across careers. The next implication of applying DST to teacher cognition and teacher expertise

emerges from interactions among a host of factors, including beliefs, knowledge, classroom experiences, institutional constraints, and emotional responses. Finally, when applying DST to teacher cognition, the researcher should treat variability not as noise but as evidence of development and change. This means researchers should look for evidence of instability preceding change, fluctuations in beliefs, temporary regressions, and adaptive variability.

4. The Developmental Nature of Teacher Expertise

The developmental nature of teacher expertise is now widely understood as a long-term, experiential, reflective, contextually situated, and non-linear process, rather than the simple accumulation of teaching techniques or declarative knowledge. Research across teacher cognition, expertise studies, and professional learning consistently portrays expertise as emerging through the interaction of beliefs, knowledge, practice, reflection, and environmental influences over time.

For example, when Larsen-Freeman [10] observes pre-service teachers during practicum, they demonstrate what she calls the inert knowledge problem. In teacher education programs, pre-service teachers gain knowledge of methods, techniques, and theories of teaching and learning, but they often cannot apply them in real-world situations. For Larsen-Freeman, this is synonymous with students who struggle to apply memorized grammar rules to spontaneous speech; pre-service teachers often struggle to translate theoretical pedagogical knowledge into classroom practice.

Consequently, teacher expertise is increasingly understood as a developmental process that evolves through experience, reflection, contextual adaptation, and ongoing professional learning rather than through the acquisition of static skills or knowledge alone. Expertise develops as teachers integrate content knowledge, pedagogical knowledge, beliefs, and classroom experience into increasingly sophisticated professional judgment [7]. Expert teachers do not merely possess more knowledge than novices; they organize, interpret, and apply knowledge differently in response to complex instructional contexts. Their expertise is embedded in their ability to make spontaneous classroom decisions, their situational awareness, their pattern recognition, and their use of adaptive problem-solving [11].

4.1 Experiential Processes

Expertise develops through trial and error; that is, teachers learn by doing. This experiential character is a central feature of the development process of teacher expertise. That means teaching expertise emerges through repeated engagement with classroom practice, where teachers test assumptions, refine instructional routines, and adapt their beliefs and practices in response to learners' needs and contextual demands. Tsui's [12] research on second language teachers demonstrates that expertise is grounded in situated practice and develops through teachers' interpretations of classroom experience rather than through formal knowledge alone. Likewise, Freeman [5] argues that teacher development involves the gradual restructuring of teachers' thinking and decision-making processes through engagement in teaching itself.

Because teaching expertise develops through experience and trial and error, teachers can be viewed as agents who practice bricolage [13]. Bricolage is the ability to dynamically use whatever resources are available in the immediate environment to solve unexpected problems. Therefore, teacher development

should not be about training teachers to fit into a pedagogic straightjacket or a rigid methodological mold; teacher education should be about empowering them to adapt to changing, unpredictable classroom variables.

4.2 Maturation through Reflection

Reflection is also fundamental to the development of expertise. Becoming an expert teacher does not happen passively. One cannot simply put in the time; it is not the number of “years on the job.” It is heavily driven by deliberate reflection and professional agency. Through reflective practice, teachers examine classroom events, evaluate instructional choices, and revise their beliefs, knowledge, and pedagogical strategies [14]. It involves making the tacit explicit, or what Schön [14] called “reflection-in-action” and “reflection-on-action.” This means teachers must intentionally analyze classes; the classes that went spectacularly wrong, as well as the classes that were successful. Thus, reflection supports the transformation of experience into professional learning and contributes to the maturation of teacher cognition over time. Research on teacher professional growth emphasizes that changes in practice, beliefs, and external conditions influence one another recursively rather than sequentially [15].

4.3 Non-linear Trajectories

Importantly, teacher expertise develops along non-linear trajectories. Development rarely proceeds through orderly, stage-like progression; instead, it is often marked by variability, setbacks, periods of stability, and sudden change. Expertise emerges from complex interactions among individual cognition, professional context, institutional structures, and classroom realities [16]. This view aligns closely with Dynamic Systems Theory, which conceptualizes development as adaptive, context-sensitive, and self-organizing across multiple timescales [17], [18].

5. Applying DST in the Study of Teacher Development

If one wants to apply DST to the study of teacher development, teacher cognition, and teacher expertise, it will require a complete shift in how the researcher collects data, views change, and evaluates professional competence. Professional development should not be treated as a neat, linear progression through training modules; researchers must study teaching as an unpredictable, contextually dependent, and ecological phenomenon. Thus, based on the theoretical frameworks outlined by Larsen-Freeman & Cameron [19], applying DST to teacher development requires four methodological and conceptual shifts:

- 1) Longitudinal Tracking of Micro-Development
- 2) Mapping the Interconnected "Teacher Psychology" System
- 3) Studying the Interaction of Timescales
- 4) Shifting Focus from "Inputs" to "Affordances" and Agency

When studying the interactions between knowledge, beliefs, and practices, a DST perspective assumes that teacher cognition develops continuously through moment-to-moment interactions between

teachers and their instructional environments. Consequently, studying teacher beliefs, knowledge, and practices requires longitudinal approaches that capture developmental processes rather than static snapshots. A snapshot of a single moment in time is problematic because teacher growth is non-linear and is subject to periods of expansion and periods of contraction. So, using a cross-sectional, one-shot survey to collect data will not capture growth or development. Instead it offers information about that moment in time. Consequently, researchers must track teachers over long periods using frequent, dense data collection points.

Traditionally teacher cognition research and research on teacher development has over relied on interviews, questionnaires, and other kinds of cross-sectional observations. Although these methods are useful to record the thoughts, opinions, beliefs and recollections of that moment in time, by themselves they are not able to measure the process of change, development or growth. That's because these methods frequently assume that beliefs and knowledge are relatively stable constructs. DST instead treats variability as meaningful evidence of development [17]. Small fluctuations in instructional decision-making, reflective thinking, or classroom behavior may indicate cognitive restructuring and adaptation.

To observe the interactions among beliefs, knowledge, and practices DST recommends using a multi-method approach that would combine several of the following techniques:

- repeated classroom observations,
- stimulated recall interviews,
- reflective teaching journals,
- video-based lesson analysis,
- and longitudinal case studies conducted over months or years.

For example, a researcher might examine how a teacher's stated beliefs about communicative language teaching shift across a semester as instructional issues arise. How does the teacher maintain or adapt her beliefs of communicative language teaching when faced with classroom management challenges, institutional constraints, and student responses? These variables may reshape instructional practices and overtime may influence her beliefs. DST does not treat inconsistencies between beliefs and practices as "problems," because this variability becomes evidence of ongoing adaptation and system reorganization.

Microgenetic analysis is especially important because it allows researchers to observe developmental change as it unfolds in real time [20]. Changes in teacher cognition may emerge gradually through repeated perturbations, reflection, and experimentation rather than through sudden linear progression. This can be seen quite explicitly in the growth from novice to expert teacher.

For example, in most TESOL Professional Development courses novice teachers will be introduced to communicative language teaching as a core approach to instruction, but a novice's understanding and

implementation of that approach will be quite different from the understanding and implementation of an expert practitioner. To move from the novice to the expert requires cognitive and behavioral shifts. Novice teachers often rely heavily on rigid, explicit, textbook pedagogical rules or what Larsen-Freeman [10] has called the inert knowledge problem. They have limited situational awareness, focus intensely on their own performance so student learning is often overlooked or undervalued, and view classroom disruptions as isolated crises instead of opportunities or teachable moments. On the other hand, expert teachers tend to possess highly integrated, tacit mental schemata [12] built from years of experience. They exercise automaticity in routine tasks, exhibit "with-it-ness;" that is, "eyes-in-the-back-of-their-heads" and the ability to read a classroom instantly [21], [22], and intuitively adapt their lessons in real time based on implicit student cues.

CONCLUSION

In conclusion, teacher development is an inherently dynamic, contextual, adaptive, and nonlinear process. Although Dynamic Systems Theory (DST) is a relatively recent framework in educational research, foundational studies in teacher cognition anticipated its core tenets decades ago. Early scholars recognized that teacher beliefs, knowledge, and practices do not exist in isolation but form an interconnected cognitive system. For instance, Nespor [6] highlighted that teacher beliefs are episodic, context-dependent structures continually reshaped through classroom realities and ongoing reflection. Shulman [7] conceptualized pedagogical content knowledge as an emergent, evolving amalgam of dynamic understandings. Pajares [8] characterized teacher beliefs as self-reinforcing, nonlinear systems that heavily filter new knowledge. Together, these pioneering works demonstrated that teacher growth involves continuous, non-linear adaptation long before DST gained prominence in the field.

Dynamic Systems Theory provides the formal framework to explicitly study these complex educational processes. As both a transdisciplinary metatheory and a specific model, DST focuses on self-organization, non-linearity, and component interactions over multiple timescales. Crucially, DST does not replace or invalidate earlier teacher cognition scholarship. Instead, it provides a robust theoretical vocabulary and methodological framework to formalize, observe, and measure the exact phenomena that earlier scholars had already identified. Concepts like self-organization, feedback loops, and stability give precise language to the messy, "ill-structured" and "entangled" realities of teacher growth described by early researchers.

Applying DST to teacher development requires four major methodological and conceptual shifts to move beyond restrictive static snapshots. First, researchers must transition from cross-sectional, one-shot surveys to dense, longitudinal tracking of micro-development. Second, they must actively map the interconnected "teacher psychology" system where cognitive, emotional, behavioral, and environmental variables interact. Third, research must analyze the interaction of multiple timescales, linking moment-to-moment classroom decisions to long-term career trajectories. Finally, the focus must shift from evaluating top-down "inputs" to exploring teacher affordances and agency. By treating real-time variability, instability, and temporary regressions as meaningful evidence of development rather than noise, these methods capture how teacher expertise truly reorganizes over time.

These shifts carry profound implications for the future of teacher education and long-term professional development. Professional learning should no longer be conceptualized as a neat, linear progression through uniform, isolated training modules. Instead, teacher education programs must directly address the "inert knowledge problem" by embedding theoretical concepts within real-world, situated classroom practices. Rather than forcing educators into a "pedagogic straightjacket" or a rigid methodological mold, professional development must empower teachers as active agents. It should intentionally nurture their capacity for bricolage; that is, the ability to flexibly adapt and utilize immediate environmental resources to solve unpredictable classroom variables. Ultimately, viewing teacher development through a dynamic lens allows institutions to cultivate resilient, reflective, and truly expert practitioners who can fluidly adapt to complex educational ecologies.

REFERENCES

- [1] S. Borg, "Teacher Cognition in Language Teaching: A Review of Research on What Language Teachers Think, Know, Believe, and Do," *Language Teaching*, 36(2), pp. 81–109, 2003.
- [2] S. Borg, *Teacher Cognition and Language Education*, Continuum, London, 2006.
- [3] S. Borg, "Language Teacher Cognition: Perspectives and Debates," in *Second Handbook of English Language Teaching*, X. Gao (ed.), Springer, Cham, pp. 1149–1170, 2019.
- [4] S. Borg, "The Impact of In-service Teacher Education on Language Teachers' Beliefs," *System*, 39(3), pp. 370–380, 2011.
- [5] D. Freeman, "Teacher Training, Development, and Decision Making: A Model of Teaching and Related Strategies for Language Teacher Education," *TESOL Quarterly*, 23(1), pp. 27–45, 1989.
- [6] J. Nespore, "The Role of Beliefs in the Practice of Teaching," *Journal of Curriculum Studies*, 19(4), pp. 317–328, 1987.
- [7] L. S. Shulman, "Knowledge and Teaching: Foundations of the New Reform," *Harvard Educational Review*, 57(1), pp. 1–22, 1987.
- [8] F. Pajares, "Teachers' Beliefs and Educational Research: Cleaning Up a Messy Construct," *Review of Educational Research*, 62(3), pp. 307–332, 1992.
- [9] E. Thelen and L. B. Smith, "Dynamic Systems Theories," in *Handbook of Child Psychology: Vol. 1. Theoretical Models of Human Development*, W. Damon and R. M. Lerner (eds.), 6th ed., John Wiley & Sons, Hoboken, NJ, pp. 258–312, 2006.
- [10] D. Larsen-Freeman, "Complex, Dynamic Systems: A New Transdisciplinary Theme for Applied Linguistics?" *Language Teaching*, 45(2), pp. 202–214, 2012.
- [11] D. C. Berliner, "Learning about and Learning from Expert Teachers," *International Journal of Educational Research*, 35(5), pp. 463–482, 2001.
- [12] A. B. M. Tsui, *Understanding Teacher Expertise*, Cambridge University Press, Cambridge, 2003.
- [13] J. L. Kincheloe and K. S. Berry, *Rigour and Complexity in Educational Research: Conceptualizing the Bricolage*, Open University Press, Maidenhead, 2004.
- [14] D. A. Schön, *The Reflective Practitioner: How Professionals Think in Action*. Basic Books, New York, 1983.

- [15] D. Clarke and H. Hollingsworth, "Elaborating a Model of Teacher Professional Growth," *Teaching and Teacher Education*, 18(8), pp. 947–967, 2002.
- [16] V. D. Opfer and D. Pedder, "Conceptualizing Teacher Professional Learning," *Review of Educational Research*, 81(3), pp. 376–407, 2011.
- [17] E. Thelen and L. B. Smith, *A Dynamic Systems Approach to the Development of Cognition and Action*, MIT Press, Cambridge, MA, 1994.
- [18] P. van Geert, *Dynamic Systems of Development: Change Between Complexity and Chaos*, Harvester Wheatsheaf, New York, 1994.
- [19] D. Larsen-Freeman and L. Cameron, *Complex Systems and Applied Linguistics*, Oxford University Press, Oxford, 2008.
- [20] R. S. Siegler and K. Crowley, "The Microgenetic Method: A Direct Means for Studying Cognitive Development," *American Psychologist*, 46(6), pp. 606–620, 1991.
- [21] J. S. Kounin, *Discipline and Group Management in Classrooms*, Holt, Rinehart and Winston, New York, 1970.
- [22] R. Marzano, *The Art and Science of Teaching: A Comprehensive Framework for Effective Instruction*, Association for Supervision and Curriculum Development, Alexandria, VA, 2007.