Annual Review of Applied Linguistics (2004) **24**, 303–319. Printed in the USA.
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DOI: 10.1017/S0267190504000121

14. CONSTRUCTIVIST ISSUES IN LANGUAGE LEARNING AND TEACHING

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Constructivism has emerged in recent years as a dominant paradigm in education and has had a major intellectual impact on the development of pedagogy, especially in mathematics and science. Rooted in the cognitive developmental theory of Piaget and in the sociocultural theory of Vygotsky, constructivist notions have had an impact on the development and application of technologically enhanced microworlds and on linguistic investigation into literacy and narrative development. To date, constructivism has had little impact on language pedagogy; however, the advent of content-based pedagogical paradigms as an anchor of language education has opened new opportunities for integration of interdisciplinary collaborative approaches for language teaching and learning. Furthermore, the current emphasis on standards-based accreditation and reconceptualization of teacher education programs will likely expand the horizons of language pedagogy, bringing constructivist approaches to the foreground in language teacher education and opening new avenues for linguistic and interdisciplinary classroom-based research.

Overview of Constructivism

Constructivism has been viewed as a philosophy, epistemology, and a theory of communication. In recent decades, it has emerged as a dominant paradigm in education having a major intellectual impact on the development of pedagogy and playing a major role in systemic changes, primarily in the fields of mathematics and science (Brooks, 2002; DeVries & Kohlberg, 1987; Driver, 1983; Forman & Kuschner, 1977; Gabel, 1994; Kamii, 1981, 1985; Russel, 1993; Sigel, Brozinsky, & Golinkoff, 1981; Tobin, 1993; von Glasersfeld, 1995, 1998; Wang & Walberg, 2001). The emergence of this paradigm has coincided with a shift in pedagogy away from teacher-centered information transmission models toward knowledge-centered and learner-centered approaches that focus on cognitive and social processes in learning. Constructivism as an approach to teaching and learning has evolved from psychology and information processing theories and in recent years has increasingly incorporated ideas from linguistics, anthropology, and sociology (Blumenfeld,

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Krajcik, Marx, & Soloway, 2001). Constructivism in education is rooted in notions from cognitive and social constructivism. The former is grounded in the work of Piaget (1954, 1955, 1970; Piaget & Inhelder, 1971) and accentuates cognitive development and individual construction of knowledge, and the latter emphasizes social construction of knowledge and is generally attributed to the work of Vygotsky (1962, 1978; but see Smith's [1993] contention that the social construction of knowledge is inherent in Piaget's work). Piaget's developmental theory advocates a holistic approach. Learning is a developmental process that involves change, self-generation, and construction, each building on prior learning experiences. Learning for the child occurs through construction of new understandings through reading, listening, exploration, and experience. This involves three distinct yet interrelated processes of *assimilation, accommodation*, and *equilibrium*. New experiences are *assimilated* and integrated into existing schema or into schema under construction through the process of *accommodation*. The outcome of these processes is *equilibrium*—the achievement of new understandings, coherence, and cognitive stability.

The influence of social and cultural contexts on learning and knowledge construction is underscored in Vygotsky's social constructivist theory (Vygotsky, 1978). In exploring the social origins of thought, Vygotsky advanced the view that children's thinking and meaning-making is socially constructed and emerges out of their social interactions with their environment. Children's learning is facilitated by parents, peers, teachers, and others around them in the community. Vygotsky's zone of proximal development embodies the learners' readiness to learn. It is the distance between the learners' actual developmental level and the level of their potential development. This prospective view of learners' potential for learning guides the design of problem-solving tasks and determines the level and range of scaffolding learners require for accomplishing these tasks. Active engagement, pursuit of diverse paths to discovery, concept acquisition, and external and internal scaffolding are central to the learning process. External scaffolding supports learners' acquisition of knowledge by breaking down tasks into comprehensible components, modeling, coaching, providing feedback, and appropriating responsibility for learning to learners. Internal scaffolding engages the learner in reflection and self-monitoring to enhance acquisition of concepts. Teachers too are learners in this context. They observe and identify students' zone of proximal development (ZPD); design appropriate, authentic, and meaningful learning modules; and provide instructional support and scaffolding to propel students to construction of higher levels of understanding.

Increased attention in recent years to the science of learning, knowing, and developing understandings has brought constructivism, with its emphasis on the combined cognitive and sociocultural impact on learning, to the forefront in education. Constructivism has placed the learner's individual development at the focus of instruction and learning and has acknowledged the critical role in the learning process of endogenous factors and internal schema combined with exogenous social and cultural variables that contribute to the transformation of the learner's internal schema (Cole, 1990). When the combined role of endogenous and

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exogenous variables is taken into account and constructivism is considered from both Piagetian and Vygotskian perspectives, a common misconception that constructivist learning emerges from learners' knowledge without direct instruction from teachers is refuted. Learners benefit from multiplicity of approaches and learning experiences as they extract salient information in acquiring new knowledge. They also benefit from assistance by teachers who attend to their interpretations and provide relevant guidance and scaffolding to promote meaningful learning. The constructivist experience from both Piagetian and Vygotskian perspectives creates opportunities for learners to engage in hands-on, minds-on manipulation of raw data in quest of identifying new and increasingly complex patterns, acquisition of novel concepts and construction of new understandings. The benefits of constructivist-based educational settings for learners' academic, social, and affective growth have been widely documented (Brooks, 2002; Brooks & Brooks, 1993; Duckworth, 1987; Fosnot, 1993, 1996; Gabel, 1994; Sigel & Cocking, 1977; Tobin, 1993; Tobin, Tippins, & Gallard, 1994; Wheatley, 1991).

Digital Microworlds as Constructivist Learning Environments

Constructivist notions are intrinsic to the journeys of discovery and microworlds of Alice in Lewis Carroll's *Alice in Wonderland*, and *Through the Looking Glass and What Alice Learned There,* and of Milo in Norton Juster's *The Phantom Tollbooth.* On these journeys, Alice and Milo discover concepts in literacy and numeracy through exploration, adventures, and encounters with characters that engage them in creative learning and invite them to experience alternative ways of viewing the world around them. Alice's and Milo's reactions when they emerge from these journeys reflect a burst of innovative ideas, rediscovery of possibilities, quest for new learning, and readiness for outside facilitation and scaffolding. Alice remarks, "Somehow it fills my head with ideas—only I don't know exactly what they are" (Carroll, 2003, book jacket). Milo, upon returning to the real world and readjusting to his ordinary surroundings, discovers that "in the very room in which he sat, there were books that could take you anywhere, and things to invent, and make, and build, and break, and all the puzzle and excitement of everything he didn't know—music to play, songs to sing, and worlds to imagine and then someday to make real. His thoughts darted eagerly about as everything looked new—and worth trying" (Juster, 1961, p. 256).

Imaginary microworlds like *Wonderland*, *Dictionoplis*, and the *Island of Conclusions* (in *Phantom Tollbooth*), are learning environments that transform learners' preconceptions and engage them through inquiry and discovery in the acquisition of new knowledge about the world. Digital technologies have made Alice's and Milo's microworld explorations possible for all learners within educational contexts. The integration of new technologies across disciplines and educational contexts has grown dramatically in recent years and the impact of constructivism in the development and implementation of virtual environments has intensified with the ever-increasing technological advances that have opened new possibilities. The application of constructivist approaches as instructional modes in these contexts challenges learners' preexisting suppositions and further enhances

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their construction of knowledge within virtual environments. Learners pursue investigations that lead them to a deeper understanding of literacy, numeracy, and scientific concepts. Computer, video, and wireless technologies have provided optimal media for the application of constructivist principles to learning and teaching, created communities of learners in electronic learning environments, and greatly enhanced student achievement and teacher learning (Beatty, 2003; Bransford, Brown, & Cocking, 2000; Perkins, Schwartz, West, & Wiske, 1995). The new technologies have extended learning environments to nonlinear, multidimensional, and interactive and have greatly expanded the horizons of learners beyond their local communities into a global context.

The potential of technologically enhanced environments for constructivist-based exploratory learning is not a new discovery. Over two decades ago Pappert (1980) used what he called *Piagetian learning* as the organizing principle to develop LOGO, a programming environment for children to explore domains of knowledge that had previously required didactic teaching. Rejecting the notion of digital tools that program the way children learn, Pappert used constructivist principles to create a powerful technological microworld and "a province of Mathland where certain kinds of mathematical thinking could hatch and grow with particular ease. The microworld was an incubator . . . a growing place for specific species of powerful ideas or intellectual structures" (Pappert, 1980, p. 125). Pappert's LOGO was a revolutionary concept that made computer programming a child's endeavor. By combining Piaget's concept of children as builders of their own intellectual structures with their natural spontaneous learning in interaction with the rich cultural resources that surround them, Pappert had envisioned children programmers acquiring a sense of mastery over a piece of the most modern and powerful technology and establishing "an intimate contact with some of the deepest ideas from science, from mathematics, and from the art of intellectual model building" (p. 5). Pappert's Turtle Graphics had pioneered a new subculture that brought together mathematicians, scholars, scientists, computer scientists, artists, and writers in joint exploration to develop a palette of rich simulated micorworlds and interactive animations as learning environments that can provide stimulating contexts for language elicitation and development of skills and concepts across disciplines.

Digital tools have become extremely powerful as enablers of highly exploratory virtual environments created by interdisciplinary teams. Inquiry-oriented, constructivist-based computer and video-based technologies have become powerful pedagogical tools that extend human capabilities and contexts for social interactions. They scaffold and expand student learning, enhance curriculum development and assessment, and bring real-world problem-solving issues into the classroom for deliberation. They expand professional development opportunities for teachers and build local and global communities within and across disciplines. When the technology is integrated into the curriculum and is used as part of a coherent educational approach, learners develop a deeper understanding of phenomena in the physical and social world. They can work with visualization and modeling software and visit fully immersive 3D interactive reconstructed heritage sites that are no longer in existence or are inaccessible. Such exploratory environments immerse

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learners in simulated and animated discoveries of an ancient Syngaporian heritage site (Song, Elias, Muller-Witting, & Chan, 2003) and engage them in construction of simulated cities. Technological advances have also increased access to vast resources of data and information and greatly enhanced global connections. The shift from static models drawn on paper to dynamic models in interactive media that provide visualization and analytic tools is profoundly changing the nature of scientific and mathematical inquiry (Bransford et al., 2000; Perkins et al., 1995). When integrated into the curriculum, Internet and online environments and communication create virtual microworlds that expand discourse communities beyond disciplinary boundaries and greatly enhance language development and acquisition of disciplinary concepts.

Constructivist Notions in Linguistic Research

Linguists have increasingly drawn upon Piagetian and Vygotskian perspectives to investigate the role of language in learning contexts and its development at various stages in the acquisition process. Bickerton (1990) distinguished among three types of learning: observational, experiential, and constructional, and discussed the role of language—the system of representation for sorting and manipulating information—as the enabler of constructional learning. Observational and experiential learning that are prevalent in language education contexts depend on the occurrence of external events that are outside the control of the learner, however, constructional learning transcends immediate observational and experiential events and involves knowledge construction that is based on prior observations and experience. Maximization of constructional learning will occur through increased data gathering and that will stimulate internal events in the mind of the learner. It is the learner who controls the selection of relevant raw environmental data to support formulation of inferences and decision making.

A constructivist stance is evident in the investigation of emergent and developing literacy and narration. These cognitive, developmental, socially constructed, and culturally embedded processes are viewed from a child-centered and learner-centered perspective that is compatible with constructivist notions. Research in emergent literacy and narrative development brought together linguists, psychologists, and cognitive scientists who incorporated Piagetian and Vygotskian conceptual frameworks and constructivist notions to underscore the centrality of language and the role of social and cognitive processes in the construction of knowledge and the development of literacy. Early research has targeted primarily alphabetic languages and has focused on the initial stages in children's text production and the centrality of writing to the process of language and literacy development (Dyson, 1989; Ferreiro & Taberosky, 1989; Goodman & Wilde, 1992; Harris & Hatano, 1999; McCabe & Peterson, 1991; Pontecorvo, Orsolini, Burge, & Resnick, 1996; Tolchinsky-Landsmann, 1996). The research included the impact of children's construction of early drawings on literacy development (Levin, Korat, & Amsterdamer, 1996); children's emerging construction of written texts and invented spelling (Read, 1986; Treiman, 1993), and children's construction and emerging concepts about print and reading (Clay, 1991). Piagetian and Vygotskian notions

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have also influenced research in narrative development. Appleby's (1978) study of the child's developing concept of the story investigated how children assimilate fairy tales into schema formulated through prior experiences with similar tales. Existing schema facilitate developing expectations of characters, patterns of behavior, and appropriate endings in comparable stories. Through accommodation, children construct their representation of the world from encounters embedded within their social contexts and relationships and modify and expand upon their understandings of what constitutes a fairy tale. Appleby studied the conceptual structures and modes of organization of young children's story plots and identified six stages in the development of narrative production that paralleled Vygotsky's stages of concept development.

Research into literacy development has underscored the centrality of language and communication and the role of psychological and social variables in the construction of knowledge (Barton, 1994; Spivey, 1996). Learners conduct operations that include selection, organization, and connection to make meanings and their text construction and decoding are socially motivated. Writers use prior knowledge to conjure an image of their readers as they construct texts and manipulate language to target readers of specific age groups, socioeconomic status, knowledge, beliefs, and values. For readers, meaning-making goes beyond knowing the meanings of words and combining them in grammatical categories. Readers' construction of texts is based on the background knowledge that they bring to the text that is both internally formulated and socially constructed. Recent discussion in the linguistic literature on constructivism has also included application of constructivist scholarship and approaches in applied linguistic research (McGroarty, 1998) and investigation into the role, nature, and quality of exogenous and endogenous scaffolding for language acquisition and narrative development by peers, parents, and teachers (Swain, Brooks, & Tocalli-Beller, 2002), and by the learners themselves (Ko, Schallert, & Walters, 2003).

Pedagogical issues have generally not been central to these linguistic investigations. However, research in emergent literacy and narrative development has generated a rich resource for language educators to draw upon in developing constructivist-based and standards-based learning contexts to engage children in reading and writing and enhance discovery of patterns in spellings and texts as they move from emergent to more conventional spellings and organization in text construction. Mason and Sinha (1993), for example, have drawn upon the research in emergent literacy to develop a Vygotskian model for the early childhood classroom and identified four instructional steps for the acquisition of literacy concepts. These combine home and classroom language, literacy, and play activities and teachers' mediation, support, and close observation of students' changing levels of competence. The first step, *natural involvement*, requires teachers to engage students in real or simulated meaningful literacy activities. In the second step, *mediated learning,* teachers guide students' participation in activities and prepare them through modeling and coaching to become self-directed learners. In the third step, *external activity*, students engage in self-directed and independent learning activities, alone or with peers, with occasional coaching. Finally, in the fourth step,

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internal or independent activity, students proceed unaided through processes of reflection, inquiry, problem solving, and task performance.

Constructivism and Language Pedagogy

Constructivism has hitherto not played a visible role in language pedagogy and teacher education, although notions that are central to constructivism have been integrated into language education through other pedagogical models. In recent years, language pedagogy has integrated a rich palette of instructional approaches that underscore the centrality and diversity of learners and their active engagement in authentic and meaningful pursuits as individuals and within communities of learners. These have been integrated in curriculum design, assessment, and instructional practices and have included cooperative learning (Johnson & Johnson, 1984; Kessler, 1992; Nunan, 1988, 1992) and paradigms that foster learners' autonomy, action research, reflective practices, community partnerships, and alternative assessments that are embedded in their social and cultural environments and educational contexts (Benson, 2001; Brown, 2004; Burns, 1999; Edge, 1996, 2002; Freeman & Richards, 1996; Gebhard & Oprandy, 1999; Graves, 1996; Johnson, 1999; Murphy & Byrd, 2001; Nunan & Lamb, 1996; Richard-Amato, 2003; Shohamy, 2001; van Lier, 1996; Zamel & Spack, 2002). The recent dramatic growth in the ethnic and linguistic diversity in schools has underscored the need for reconceptualizing language teacher education and for placing a greater emphasis on the centrality of sociocultural processes in preparing professionals (Freeman & Johnson, 1998; Hall, 2002; Murrell, 2001; Prabhu, 1996; Johnson, 2000). Increased attention has been given to teachers' own self-image as emerging professionals in both ESL and EFL contexts (Pearson Casanave & Schecter, 1997), and to their developmental discourse about the process of becoming a professional (Bailey & Nunan 1995; Edge, 2002).

Changing demographics have also directed attention to the performance of English language learners (ELL) in schools and research findings on their poor performance in academic areas have underscored the need for a paradigm shift in language pedagogy that led to the advent of Content-Based Language Learning (CBLL) (Brinton, Snow, & Wesche, 1989; Crandall, 1993; Mohan, 1986; Mohan, Leung, & Davison, 2001; Short, 1993; Snow, Met & Genesee, 1989; Stoller, this volume). The approach has increasingly grounded language teaching in academic content across disciplines and has changed the focus of language teaching from teaching language in isolation to its integration in disciplinary content in elementary, secondary, and tertiary contexts in the United States and abroad (Crandall & Kaufman, 2002; Snow & Brinton, 1997). CBLL has provided scaffolding for higher academic success for language learners by grounding language learning in relevant and meaningful content that is aligned with the core curriculum of the school and the specialized academic standards of the respective disciplines. Application of CBLL has also raised awareness of the specialized language of mathematics (Cocking & Mestre, 1988; Crandall, Dale, Rhodes, & Spanos, 1990; Cuevas, 1984) and social studies (Short, 1994) and the challenges involved in integrating the specialized subject matter into language classes. Lack of expertise in the subject matter of the respective disciplines has motivated language educators, to explore collaborative paradigms that

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have included integrated or linked courses and highly collaborative coteaching or separate and distinct roles for language and content instructors (Crandall & Kaufman, 2002; Snow & Brinton, 1997). Preoccupation with these matters has left the issue of the specialized pedagogy of the disciplines virtually untouched. Integration of the constructivist pedagogy, so prevalent in mathematics and science, has largely been ignored in the language education literature. Consequently little is known about preparing language teacher candidates for embedding constructivist approaches for teaching scientific and mathematical concepts within the framework of language pedagogy.

The effective preparation of language teacher candidates has become even more critical in recent years for a variety of reasons. The changing demographics combined with greater emphasis of language across the curriculum (American Association for the Advancement of Science, 2001) have advanced the impact and visibility of language educators. In addition to providing language-enhanced and content-rich academic preparation for ELL, their role in school settings and in the community has significantly expanded (Clegg, 1996). Language educators increasingly engage in interdisciplinary collaborative activities and curriculum design; as advocates for English language learners, they develop and conduct workshops for colleagues across disciplines to raise cross-cultural awareness and to increase sensitivity to learners' linguistic, academic, social and affective needs. The challenge for teacher education programs has become the design and application of paradigms to prepare teacher candidates for their reconceptualized and greatly expanded professional role in the school and the community as well as the integration of constructivist paradigms that are prevalent in the disciplines within which language instruction is currently embedded. Such a shift in language pedagogy will engage language educators in new patterns of interdisciplinary collaborations and in rethinking of the knowledge base and pedagogical practices in teacher education programs (Kaufman, 1996, 1997, 2000; Kaufman & Grennon Brooks, 1996).

Constructivism and Teacher Change—The Challenge For Teacher Education

Despite research-based developments in pedagogy and the documented benefits of constructivist approaches, the prevalence of traditional teacher-centered classrooms across disciplines has remained a major challenge for advocates of constructivist approaches (Brooks, 2002; Sexton & Griffin, 1997a). The pervasiveness of traditional instructional practices in schools is due to several contributing factors. First, instructional practice hinges upon prior educational experiences that contribute to teachers' beliefs about teaching and learning and shape their teaching behavior in ways that are resistant to change (Cuban, 1993; Johnson, 1992; Pennington, 1995; Richardson, 1990; Shavelson & Stern, 1981). Second, the recent emphasis on accountability, performance-based assessment, and standards-based teaching have often reintroduced lecture and information-transmission instructional modes and have decreased the impetus for innovative and experiential learner-centered pedagogical approaches. Third, the serious shortage of teachers has set in motion alternate routes to obtaining teacher certification. These more intensive

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but shorter routes to certification have of necessity included little if any exposure to constructivist approaches, fewer opportunities for research and guided clinical practice, and less time and fewer outlets for reflective practice. Since it is these experiential modes that trigger and expedite change in prior suppositions and practice and advance professional growth, reconceptualization of pedagogical practice and adoption of constructivist pedagogy is less likely to occur among alternate route candidates.

For constructivist practices to be more prevalent in schools, they must be more widespread in teacher preparation. Change in teacher candidates is gradual and often imperceptible and is impacted by diverse developmental events that occur during professional preparation. Opportunities for teacher candidates within teacher education programs through coursework, collaborative partnerships, diverse field experiences, and sustained reflection impact the reformulation of their existing notions (Evans, 2002; Goodlad, 1990; Kaufman, 2000; Pennington, 1995). New knowledge and professional practices are individualized constructions that are socially and contextually motivated and co-constructions that occur through reciprocal learning experiences with teacher educators and peers at the university and with students and mentoring teachers in school settings. Collaboration with colleagues across disciplines further enhances accessibility to resources for developing and implementing constructivist, language-enhanced, and content-based learning environments.

Constructivism is open-ended and allows for ambiguity, flexibility, and innovative thinking that is inherent to teacher education programs that continue to evolve in alignment with emerging research. Sexton and Griffin (1997a, 1997b) underscore the open-ended quality of constructivism: "The constructivist paradigm represents a way of thinking that is inherently ambiguous and will require us to be different not just think differently. It is a journey not toward new technique but toward ever expanding epistemological positions" (Sexton & Griffin, 1997b, p. 257). Planning and application of constructivist educational contexts in language teacher education programs are described in Kaufman, (1996, 1997, 2000) and Kaufman and Grennon Brooks (1996). Reconceptualization of teacher education programs will involve teacher candidates' active engagement and autonomy, construction of knowledge through inquiry and reflection as well as involvement in interdisciplinary investigation, collaborative endeavors, fieldwork opportunities for experiential learning, and self-observation and evaluation. In such settings, close observation of teacher candidates allows teacher educators to glean important insights into teacher candidates' assimilation and accommodation of new knowledge, construction of ideas about teaching and learning, and their acquisition and development of the indispensable skills and professional dispositions for embarking on their chosen careers. Language and communication are integral to the creation of constructivist learning environments. Choice of language and modes of interpersonal communication in the classroom can enhance or inhibit the creation of constructivist learning environments. In striving to promote autonomy, creativity, and engagement, teachers' choice of scripts can powerfully motivate or block such endeavors (Stigler & Hiebert, 1999). Linguistic research of classroom discourse would greatly increase

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awareness of teachers' scripts and their impact on creating constructivist classroom contexts and enhancing student learning.

Constructivism and Standards-Based Teacher Education

The thrust for preparing teacher education programs and institutions for national accreditation by the respective specialized professional associations and accrediting agencies has provided a catalyst for reevaluation and reconceptualization of organizational structures, curricular content, and clinical experiences in teacher education programs (Williams, 2000). Although perceived by many as prescriptive, when approached from a constructivist stance, the accreditation process will likely expand the horizons of teacher preparation through creative and enriching cross-disciplinary endeavors. A critical reflective outlook into current practice, performance-based accountability, a focus on diversity, and partnerships within and beyond the university are an integral part of this process. A constructivist approach to preparing programs and teacher candidates to meet professional, state, and national standards promotes research, partnership, reflection, and a joint formulation of a vision to prepare effective teachers. It permeates emerging institutional conceptual frameworks and engages participants in inquiry and discourse within and across disciplines in the redesign of curriculum and learning experiences, and in alternative assessment approaches for improving learning and teaching.

In recent years there has been a growing consensus that amalgamation of a strong foundational knowledge of the discipline with effective pedagogy is key to preparing qualified teachers and educational reform (Darling-Hammond, 2001; Interstate New Teacher Assessment and Support Consortium [INTASC], 1992, 2002; National Board for Professional Teaching Standards [NBPTS], 1991; National Council for Accreditation of Teacher Education [NCATE], 2001; National Council of Teachers of Mathematics [NCTM], 2000; National Research Council/National Science Foundation [NRC/NSF], 1996; TESOL, 2002). Language development across the curriculum, interdisciplinary collaboration, and diverse clinical practice opportunities have also been identified as high priority issues for all disciplines in teacher education and have been integrated into the professional standards for teacher candidates and practicing teachers (INTASC, 1992; NBPTS, 2001). The recent reformulation of standards for teacher candidates that were originally developed by the Interstate New Teacher and Support Consortium (INTASC) in 1992 attests to melding of pedagogically focused standards with standards of the respective disciplines. This further underscores the strengthening linkages among foundational theory of the respective disciplines and pedagogical practice achieved though interdisciplinary collaborative processes. Among the first of these redesigned standards, collaborative project of INTASC with the National Science Teacher Association has resulted in new integrated standards for science teacher candidates (INTASC, 2002). Constructivist notions that permeate the document include grounding scientific literacy in real experience, understanding big ideas through inquiry, and applying scientific inquiry to natural events and phenomena within their social context and impact on personal and social lives. Evidence, models, and explanation of unifying concepts and processes of science are an integral part of

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scientific teaching and learning: "The teacher of science understands that being able to construct explanations is more important than to define the term" (INTASC, 2002, p. 12).

Constructivist notions, while not explicitly underscored, are pervasive in the TESOL standards for teacher education programs (TESOL, 2002). Drawing on linguistic research, the document endorses preparation of candidates who understand the "constructive nature of language" and "how meaning is constructed" and are able to apply this knowledge in educational settings and to use "*linguistic scaffolding*" to enhance student learning (Standard 1.b). The document further underscores the grounding of language in the content area and the melding of a strong linguistic foundation for teacher candidates with a solid grounding in the respective disciplines of the core curriculum. The challenge for language teacher education programs is to reformulate current practices to integrate linguistic research and pedagogy with constructivist notions for the teaching of language through science and mathematics. Integration of cognitive and social constructivist notions into language teacher education will enhance teacher candidates' construction of deeper understandings of mathematical and scientific concepts and will enable them to construct learning environments that will support their own students' cultural identities, language and literacy development, and academic achievement.

Conclusion

The contribution of constructivism to mathematics and science pedagogy, to the development and application of new technologies, and to linguistic research in literacy and narrative development is indisputable. The role of constructivism in language pedagogy has hitherto been minimal but will undoubtedly become more prominent in the coming years and will carve new pathways for teacher candidates' emancipation as professionals. The integrated language and content paradigm as an anchor to language learning and the standards-based program reform and accreditation have created a common goal for educators and interdisciplinary linkages in the preparation of teacher candidates. The process has already engaged many educators across disciplines in joint reformulation of the vision and conceptual framework of teacher education. Integration of constructivism in language pedagogy will further open new avenues for linguistic and interdisciplinary research. Collaborative research among language, mathematics, and science educators and researchers will unravel the symbiosis of emergent literacy and numeracy and the acquisition of language and scientific concepts within a constructivist framework.

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