# Poster: Zone of Self-Efficacy Development (ZSED) Model: A Framework for Teacher Growth in Community-Relevant Engineering Design (CRED) Implementation.

**Adesola Samson Adetunji, University of North Dakota**

Adetunji Adesola is a graduate research assistant in the Department of Chemical Engineering at the University of North Dakota and works at the Center for Engineering Education Research (CEER). His research focuses on culturally relevant engineering design, engineering identity development, and promoting equity and inclusion in K-12 STEM education. He employs mixed methods approaches to advance engineering workforce development and foster inclusive practices within engineering education.

**Dr. Frank M. Bowman, University of North Dakota**

Dr. Frank Bowman is Thomas C. Owens Endowed Chair of Chemical Engineering, Professor, and Chair in the Department of Chemical Engineering at the University of North Dakota. He holds a Ph.D. from the California Institute of Technology and a B.S from Brigham Young University

**Julie Robinson, University of North Dakota**

Dr. Julie Robinson is an Assistant Professor at the University of North Dakota and the Director of UND's Center for Engineering Education Research. Her research explores strategies for broadening access and participation in STEM, focusing on culturally relevant pedagogy in science and engineering. She also investigates strategies for increasing representation in STEM through teacher professional learning opportunities and by exploring the impact of group gender composition on girls' motivation and engagement. Dr. Robinson is a PI and Co-PI on several NSF sponsored grant projects which focus on teacher professional learning and self-efficacy with implementing culturally relevant engineering education, connecting to place and community, and centering culture and Indigeneity within STEM education. Dr. Robinson has over twenty years of K – 12 teaching experience, including seven years as a teacher leader of professional development in the Next Generation Science Standards, the Common Core State Standards in Mathematics, and in elementary science and engineering pedagogy.

**Adesikeola Olateru-Olagbegi, University of North Dakota**

'Sike Olateru-Olagbegi is a doctoral level student in Education, Health and Behavior Studies (EHBS) with specialization in Instructional Design and Technology (IDT) in the College of Education and Human Development (CEHD) at the University of North Dakota (UND). She is a Graduate Research Assistant with the Center for Engineering Education Research (CEER), UND. Sike's research focuses on the design, implementation, and evaluation of microlearning interventions in diverse settings. Her research interests include Instructional Design, Educational Technology, Workforce Education and Development, Problem-based Learning, and Interdisciplinary Education.

# Zone of Self-Efficacy Development (ZSED) Model: A Framework for Teacher Growth in Community-Relevant Engineering Design (CRED) Implementation.

## 1. Introduction

Engineering education increasingly emphasizes pedagogical strategies that connect learning to students' lived experiences and community contexts [1]. Community-Relevant Engineering Design (CRED) exemplifies this approach by framing engineering as a socially embedded, human-centered practice that integrates technical problem-solving with community knowledge, cultural relevance, and ethical considerations [2]. While CRED holds promises for enhancing participation and relevance in engineering education, its practical implementation in classrooms imposes significant cognitive, pedagogical, and emotional demands on K-12 teachers [3], [4], [5]. Professional development (PD) initiatives aligned with CRED and similar instructional frameworks often prioritize exposure to lesson planning, curricular resources, design processes, and teaching strategies [6], [7]. However, research on K-12 STEM teachers and engineering education learning indicates that access to instructional content alone does not ensure sustained classroom implementation [4]. Teachers' beliefs about their capabilities – particularly their self-efficacy – are critical in determining whether they adopt, adapt, and maintain new pedagogical practices [8]. Despite this, many PD models assume that self-efficacy and instructional shifts develop automatically through participation in training. The phased progression of teacher self-efficacy – how confidence, autonomy, and instructional agency evolve – remains underexplored, especially in equity-focused engineering education contexts. This gap limits PD designers' and researchers' ability to intentionally support K-12 teachers as they transition from initial exposure to new initiatives like CRED to confident classroom implementation.

To address this need, this poster introduces the Zone of Self-Efficacy Development (ZSED). This conceptual framework explains how K-12 teachers' self-efficacy develops progressively as they learn to implement new instructional approaches in the classroom. ZSED is presented as a literature-based conceptual and design framework intended to guide PD development and inform future research, rather than as a validated theory.

### Objectives and Contributions

1. To conceptualize the staged development of K-12 teachers' self-efficacy and confidence in implementing Community-Relevant Engineering Design (CRED) through PD.
2. To introduce the Zone of Self-Efficacy Development (ZSED) as a literature-grounded conceptual framework that can be used for designing, sequencing, and evaluating PD.
3. To provide an analytic lens for examining how K-12 teacher confidence, autonomy, and instructional practice evolve across PD experiences and classroom contexts.

## 2. Community-Relevant Engineering Design (CRED)

Community-Relevant Engineering Design (CRED) is an equity-oriented instructional approach that situates K-12 engineering education in authentic community contexts and emphasizes cultural relevance [9]. CRED emphasizes student engagement with authentic, real-world challenges that are significant to their local communities. This approach extends beyond technical proficiency by integrating engineering design practices with social awareness, cultural responsiveness, and ethical reasoning. Scholars argue that such integration is essential for preparing engineers who can address complex, socially embedded problems rather than purely technical ones [1], [2]. CRED aligns with research on the Nature of Engineering (NOE) and broader movements in engineering education that advocate human-centered design and equity-oriented pedagogies, positioning engineering as a discipline deeply intertwined with societal needs and values [10]. By foregrounding cultural relevance and ethical considerations, CRED seeks to foster inclusivity and empower students to see engineering as a tool for community improvement, thereby enhancing motivation and participation among historically underrepresented groups in STEM [11]. Instructionally, CRED follows the engineering design process (Identify, Describe, Generate, Embody, Finalize) [9], [12] and ensures that student-centered pedagogies are integrated at each stage of classroom engineering design activities (see Appendix). This approach aligns with Ladson-Billings' culturally relevant framework, which emphasizes high expectations, cultural competence, and critical consciousness for all students [13].

Implementing Community-Relevant Engineering Design (CRED) requires K-12 teachers to navigate multiple layers of complexity that go beyond technical instruction. Research on design-based learning emphasizes that teachers must facilitate open-ended problem solving, manage uncertainty, and support iterative cycles of refinement – hallmarks of authentic engineering practice [11], [14]. In CRED contexts, these challenges are compounded by the need to integrate students' cultural and community knowledge into the design process, which aligns with principles of culturally responsive pedagogy and equity-oriented STEM education [11], [13]. Such integration requires that teachers not only possess procedural knowledge of engineering design but also build confidence in managing ambiguity, fostering student agency, and navigating sociocultural dynamics within the classroom [3]. Scholars argue that these pedagogical demands often create tensions for K-12 teachers accustomed to traditional, content-driven instruction, as CRED shifts the focus toward participatory, contextually grounded problem solving [8]. K-12 teachers must balance technical rigor with responsiveness to local values and ethical considerations, positioning engineering as a socially embedded practice rather than a pure technical endeavor [2]. This complexity underscores the importance of PD models that move beyond merely providing curricular materials to cultivate teachers' adaptive expertise, reflective practice, and self-efficacy, enabling them to navigate uncertainty and promote inclusive learning environments [10]. In engineering education, teachers' self-efficacy has been closely associated with their willingness to adopt inquiry-based, project-oriented, and design-centered instructional approaches [15].

## 3. ZSED's Theoretical Rationale

The Zone of Self-Efficacy Development (ZSED) combines three complementary learning theories to create a teacher professional development model that effectively builds teachers' self-efficacy.

Kolb's Experiential Learning Theory [16] conceptualizes learning as a four-phase cycle that supports iterative professional growth. Within this cycle, teachers first engage in concrete experiences through hands-on professional development activities. They then transition to reflective observation, analyzing and interpreting those experiences to identify key insights. During the abstract conceptualization phase, teachers synthesize these insights to develop or refine instructional strategies. Finally, through active experimentation, they implement and test these strategies in classroom contexts, generating new experiences that continue the learning cycle.

Vygotsky's Sociocultural Theory [17] introduces the concept of the Zone of Proximal Development (ZPD), which characterizes the gap between a person's current capabilities and their potential performance with appropriate support. Within this framework, learning is facilitated through scaffolding that gradually fades as competence increases, as well as through social interaction in which K-12 teachers collaborate with more knowledgeable others, such as PD facilitators and peers.

Bandura's Social Cognitive Theory [18] examines the emotional dimension of teacher learning by explaining how self-efficacy develops. Teacher self-efficacy refers to educators' belief in their ability to organize and carry out the actions needed to reach instructional goals. Self-efficacy theory suggests that a person's belief in their ability to succeed can be built and enhanced through four key sources. Mastery experiences, which involve successfully implementing new teaching methods, constitute the strongest evidence of ability and directly increase teachers' confidence. Vicarious experiences, such as observing peers or facilitators use similar strategies, help teachers internalize techniques and develop the belief that they can succeed as well. Verbal persuasion from mentors, colleagues, and PD facilitators provides encouragement and constructive feedback that supports teachers' efforts to adopt new methods. Lastly, teachers' emotional and physiological states affect how they perceive their skills; managing anxiety and fostering positive feelings during challenging tasks improve perseverance and build strong self-efficacy.

These theories are complementary: Kolb describes what learners do, Vygotsky describes how the environment should respond to learners, and Bandura explains why learners persist in learning.

The synthesis provides a practical lens for designing and analyzing professional development while acknowledging that mastery is not an endpoint but a gateway to continued growth through iterative cycles.

The Zone of Self-Efficacy Development (ZSED) was developed through a comparative synthesis of these three established learning theories rather than by collecting primary data. Its development followed three intentional steps. First, key concepts related to learning progress, support, and autonomy were identified across the frameworks of Bandura, Vygotsky, and Kolb, including confidence-building through experience, the role of social mediation, and the transition from guided to independent practice. Second, the developmental structures of these theories were analyzed to identify patterns in how learners progress from novice to independent status, with particular attention to the gradual removal of support as competence and confidence increase. Finally, these theoretical patterns were matched with trends in the CRED and STEM PD literature, highlighting common challenges teachers face when shifting from professional development participation to classroom application. This alignment led to the development of five developmental zones, as shown in Figure 1. The presentation of ZSED in this poster, therefore, represents a conceptual synthesis grounded in theory and literature rather than an empirically validated model. The goal of this framework is to support professional development (PD) designers in intentionally organizing PD programs into developmental zones that systematically build teachers' self-efficacy for implementing the Community-Relevant Engineering Design (CRED) framework and other STEM initiatives in classroom practice.

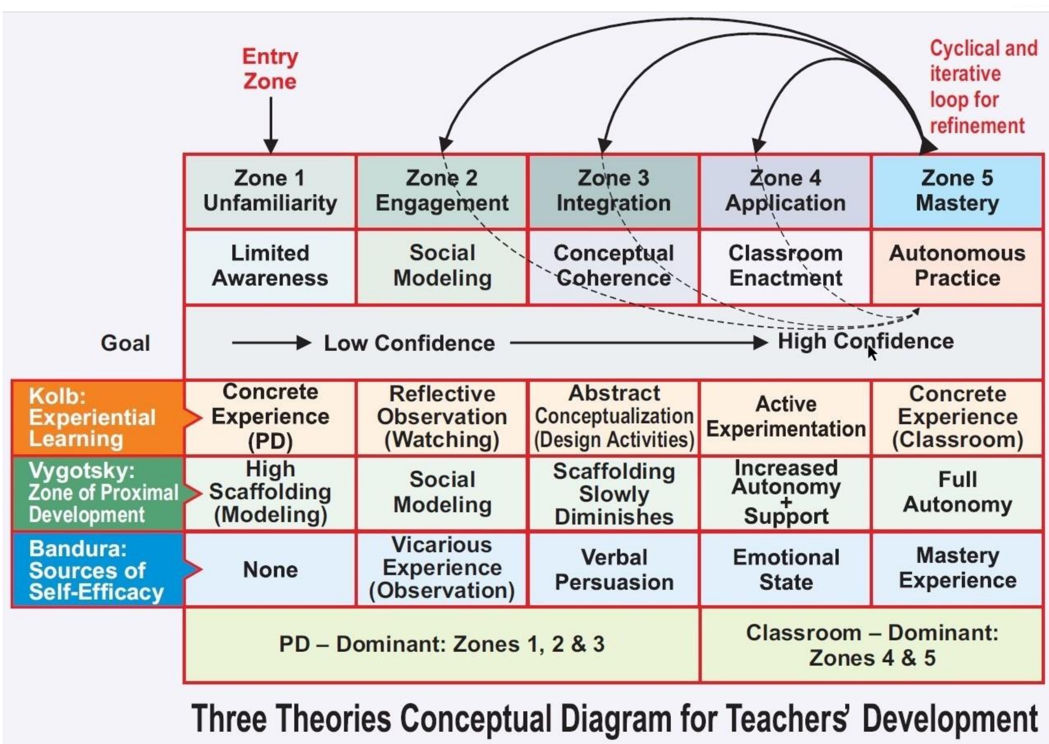


**Figure 1.** Theories Conceptual Framework

**4. The ZSED Framework**

ZSED conceptualizes the development of teacher confidence and self-efficacy as a dynamic progression through five iterative zones: Unfamiliarity, Engagement, Integration, Application, and Mastery. These zones represent evolving developmental states rather than discrete PD sessions. Additionally, ZSED distinguishes between learning in professional development settings and enactment in classroom practice, addressing a common limitation in PD models that isolate training from classroom implementation and fail to support instructional mastery. Figure 2 illustrates the conceptualization of K-12 teacher self-efficacy development from unfamiliarity to mastery level as applied to PD for Community-Relevant Engineering Design (CRED).

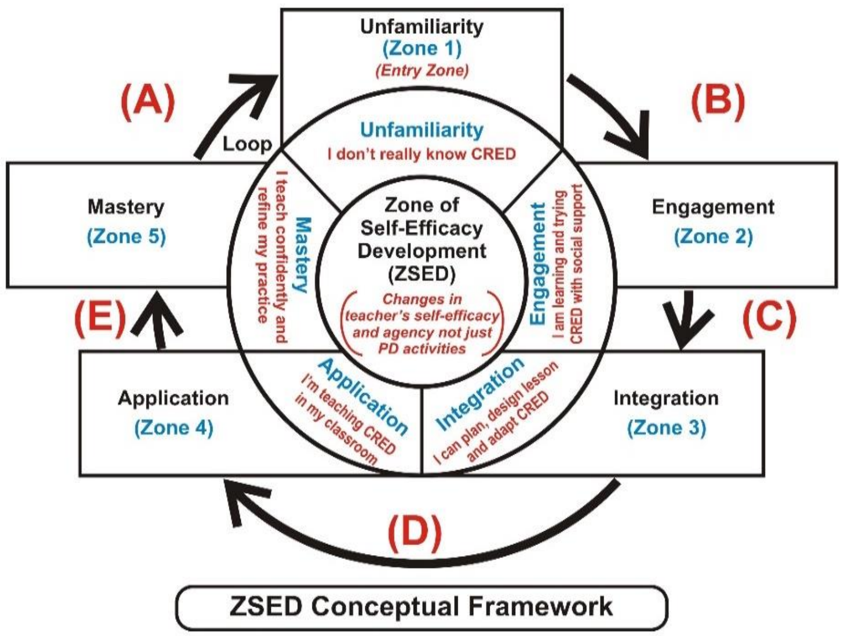


**Figure 2.** ZSED Conceptual Framework

**Zone 1: Unfamiliarity**
Teachers begin with limited awareness of CRED principles and low confidence in applying them. PD emphasizes foundational exposure, reducing fear, and providing structured scaffolds. This phase reflects Vygotsky's zone of proximal development (Scaffolding) in new tasks and Kolb's concrete experience (PD workshop).

**Zone 2: Engagement**
Teachers participate in PD activities, discussions, and collaborative learning. Confidence grows through observation and social modeling (learning by watching others perform a task successfully to shape one's own behavior). Teachers build confidence by observing peers, mentors, or facilitators effectively implement CRED. This zone reflects Bandura's vicarious

learning (observation), Vygotsky's social modeling with high scaffolding, and Kolb's reflective observation(watching)

**Zone 3: Integration**
Teachers begin to incorporate CRED principles into lesson planning and instructional design, aligning these practices with engineering design processes. Kolb's abstract conceptualization emerges as teachers synthesize theory with practice. At the same time, Vygotsky's scaffolding gradually diminishes, while Bandura's verbal persuasion continues to support teachers through encouragement, support, positive feedback, and positive affirmation during their design activities. All these factors boost teachers' confidence. Negative feedback or unsupportive feedback will be detrimental to confidence-building.

**Zone 4: Application**
Teachers implement CRED principles in real classrooms, navigating genuine constraints. Applying these principles for the first time may cause anxiety and tension, which align with Emotional State (Bandura). Also, teachers gain increased autonomy (Vygotsky) and move learning through Kolb's active experimentation. Positive feedback and successful implementation boost confidence.

**Zone 5: Mastery**
Teachers demonstrate confidence, adaptability, and leadership. They refine instruction, mentor peers, and design new CRED-based activities. Bandura's mastery experiences and Kolb's iterative learning cycle are fully realized, and teachers operate with the full autonomy described by Vygotsky. Mastery does not mean teachers have learned everything they need; new challenges will always prompt them to revisit seeking social support from zones 2, 3, and 4.

**Cyclical and Iterative Loop for Refinement**
Teachers may advance, revisit earlier stages, or cycle through zones as they encounter new contexts or challenges. It is also possible that a teacher may have high self-efficacy for one task but low self-efficacy for another. This fact makes revisiting zones to learn and receive support for low-self-efficacy tasks a key component of the ZSED PD model. Within the conceptual framework of the theories, a distinctive feature is the iterative loop that originates in Zone 5 (Mastery) and returns to Zones 2, 3, and 4. This cyclical, iterative loop acknowledges that master teachers remain, learners who re-enter the cycle in response to new challenges. This framework emphasizes that effective professional development must be cyclical, personalized, and responsive to individual teachers' needs, rather than a linear, one-size-fits-all progression. An individual teacher can re-enter the cycle at the zone where they perceive a need for support and progress back to mastery (Zone 5).

## 5. Implications, Limitations, and Conclusions

Although developed in the context of CRED, ZSED is not limited to CRED-focused PD and can be applied to various engineering education and instructional settings. It is a structured PD program aligned with [19] suggestions that integrating structured PD activities, which promote teacher interaction and collaboration, especially during lesson planning, is recommended to strengthen community building among participants.

The ZSED framework provides PD designers with a structured method for aligning support to teachers' evolving developmental stages. Early PD should focus on scaffolding and sense-making rather than immediate classroom application. In later phases, ongoing coaching, feedback, and opportunities for reflection during real practice become crucial. By differentiating between PD-focused and classroom-dependent phases, ZSED helps avoid unrealistic expectations about teacher readiness and encourages lasting, equity-focused instructional change. As a new conceptual framework, ZSED encourages empirical investigation rather than asserting validation. Future research might include qualitative studies exploring teachers' experiences across the ZSED's five zones, design-based research testing PD interventions aligned with the ZSED, and secondary analyses mapping existing PD data to the framework. ZSED is intentionally designed to support replication, critique, and refinement across different contexts.

This initial work is inherently conceptual and does not yet incorporate original empirical data. Nonetheless, it makes a substantive contribution by explaining the developmental dimensions of K-12 teacher self-efficacy within equity-oriented engineering education. By integrating established theoretical constructs and principles of professional development design, the ZSED framework provides a foundational structure to guide subsequent scholarly inquiry and practical implementation. Moreover, ZSED is intentionally articulated as a provisional and generative framework, designed to invite scholarly collaboration, empirical examination, and iterative refinement. Such ongoing development is essential for advancing sustainable, community-responsive approaches to engineering education.

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# Appendix: CRED Framework