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Culturally Responsive Pedagogical Knowledge: An Integrative Teacher Knowledge Base for Diversified STEM Classrooms

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Abstract: Teaching can be challenging, especially when teachers are under-prepared to enter a workforce with a constantly changing landscape. Preparing teachers for STEM content has generated multiple approaches from varying perspectives. While some scholars advocate for content expertise, others promote pedagogy or social context as approaches for translating STEM content for students. Yet, many contend that teachers must be culturally knowledgeable to respond to student diversity effectively. While these arguments are valuable and needed, many have not considered the interconnectedness of these approaches, often used in silos. This conceptual paper unpacks some of these arguments using the social constructivism theory of learning as the epistemic lens to examine and interpret what STEM teacher knowledge should encompass in the 21st-century diversified classroom. After thoroughly evaluating the core elements of three commonly used teacher constructs, this paper presents an integrative, holistic teacher knowledge—culturally responsive pedagogical knowledge (CRPK) framework that considers the necessary qualities that teachers must possess that are functional, content-focused, and pedagogically inclusive. The proposed CRPK construct would be a valuable programmatic tool for teacher preparation, curriculum development, and classroom praxis.

Keywords: constructivism; inquiry-based teaching; pedagogical content knowledge; cultural competency; culturally relevant pedagogy; culturally responsive teaching; technology; STEM education

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> *"We engage in teaching. . . to develop understandings, skills, and values needed to function in a free and just society"*
> *~Shulman, 1987, p. 14* [1].

1. Introduction

Global and human activities, such as climate change, technological advancement, increasing diversity, the COVID-19 pandemic, etc., add new dimensions to teaching and learning that reflect education's dynamic nature. Historically, global and national events have prompted a shift in educational practices. For instance, many education reforms occurred after the National Commission on Excellence in Education's (NCEE) report "A Nation at Risk," spurred by the Soviet Union's (1957) successful launch of its first satellite, Sputnik [2]. This event sparked various discourses on the state of America's science and mathematics education and teacher quality, resulting in many reforms and the creation of education standards by the National Research Council [3]. Groups, such as the Carnegie Taskforce, the National Science Foundation (NSF), the National Education Association (NEA), the American Federation of Teachers (AFT), the National Science Teachers Association (NSTA), the National Council of Teachers of Mathematics (NCTM), educational researchers/scholars, and other national initiatives, sought new ways to address and improve teacher quality and practical approaches to science and mathematics education. Although the NSF has continued to promote and invest heavily in STEM education, a recent report, Rising Above the Gathering Storm, by the Committee on Prospering in the Global Economy of the 21st Century, indicates that more is needed to enhance the nation's global competitiveness.

This paper draws from an extant body of literature to argue the need to enhance teachers' professional knowledge in response to the current structure and changes in today's classrooms. There is a need to address what teachers require to educate all learners effectively. Using the social constructivism lens, this paper presents a professional knowledge base, culturally responsive pedagogical knowledge (CRPK), that integrates core elements of existing pieces of teacher knowledge often used in silos. While this teacher knowledge is not unique to only STEM teachers, it aligns more with the disciplinary practices of active inquiry-based, hands-on learning. The CRPK framework intersects existing teacher knowledge bases promoted by scholars whose seminal works have guided many teacher approaches used in the classroom. CRPK is a holistic, integrative, and inclusive teacher knowledge concept that enhances teachers' expertise and is a useful model for teacher education programs, practitioners, and researchers.

2. Literature Review

2.1. STEM Education, What Is It?

Like many social science terms, "STEM education" lacks a concrete definition beyond expanding the acronym of Science, Technology, Engineering, and Mathematics. However, within the context of this paper, STEM is used as the four-crosscutting content used in preparing students for learning, interpreting, connecting, and interacting with everyday activities. These four areas uniquely provide students with the ability to think critically and form the foundation for success and global workforce readiness for the 21st century. In conceptualizing the STEM acronym, the National Research Council [4] noted that STEM is a cohesive, integrated disciplinary entity that promotes the skills necessary for emerging jobs requiring students to solve real-life problems. Fensham [5] calls these attributes the "new roles for knowledge in society" (p. 166). Preparing students for the 21st century demands a holistic approach to enhance global competitiveness; therefore, teachers must be equipped with content-specific, cross-disciplinary, and cross-cultural practices that merge STEM and society.

2.1.1. Science, Technology, and Society

One aspect of change resulting from the discourse on school reform was the National Science Teachers Association's [6] position paper on Science, Technology, and Society (STS). STS was introduced to promote student-centered teaching within societal contexts. The premise was to activate students' creativity and real-world connections beyond K12 classrooms. Aikenhead [7] noted that STS aimed at developing "students' capacities to function as responsible, savvy citizens in a world increasingly affected by science and technology. Thus, students should understand the interactions between science-technology and their society" (p. 384). This STS approach allowed students to actively seek information on how science and technology relate to their daily lives, which leads to carrying out their civic duties as sufficiently literate citizens. Preparing citizens who understand the human and social dimensions of scientific practice and its consequences is essential, especially in a changing world.

2.1.2. STEM Education within a Shifting Landscape

Teaching STEM content within a shifting landscape can present challenges where teachers are inadequately prepared or paired with the appropriate tools for a diverse classroom. There is a need to critically examine how STEM content is presented for inclusivity. Due to increasing population and migration, today's classrooms have students with differing characteristics representing their cultural, racial, ethnic, and socioeconomic backgrounds. These characteristics influence their epistemology—how they perceive, receive, and process information [8]. According to Fensham [5], today's classroom uniquely differs from the corresponding conditions and contexts of the 1960s. Yet, classroom practice remains largely unchanged with regard to how material is presented to the students. More so, many teachers' backgrounds differ from their students, and their Anglo-normative schema and expectations of how students should learn or process information do not

often match. The chasm created by this disparity can impede how teachers utilize learners' individualities and sociocultural characteristics as tools for relevant teaching.

2.1.3. Education and Relevancy to Students

STEM content thrives where there is a correlation between relevancy, instructional approach, and students' perception and interest. However, despite decades of reform, few expected strides have been made in reaching all learners. Many students struggle with STEM content, resulting in fewer entering the field, especially in science and mathematics education. For example, many students leave high school believing that science is irrelevant or mathematics is not essential to their daily lives. According to Aikenhead's [9] study, "85% of graduates would not normally have enrolled in any science course unless required" (p. 237) because they prioritize their values, personal experiences, and funds of cultural knowledge of how they believe the world works over school subjects. Drawing from this study, it will be helpful to build structures and sociocultural systems that support and challenge students' lenses of STEM subjects instead of presenting rules and theories of no interest or immediate value to the students.

2.1.4. Building STEM Structures

Since the reconstruction efforts of the 1900s, many structural frameworks have been promoted to foster STEM education in various forms. Figure 1 shows a snapshot of some events that have informed current STEM education frameworks and standards since the 1900s. For example, the current science and mathematics standards were heavily influenced by the NCEE report [2], and the resulting National Council of Science Education Standards became the building block for STEM practice and the expectations of students' learning [10,11]. A careful examination of these approaches shows that they do not fully consider or capture teacher knowledge and student epistemology in a changing and diverse world. They focused on how teachers teach the content and what students should learn. However, these structures continue to evolve with the most recent, the Next Generation Science Standards (NGSS) [11], which presents a crosscutting disciplinary framework intersecting STEM content through science and engineering ideas, concepts, and practices. One of the NGSS's main objectives is to provide students with learning experiences that stimulate their interest in science, enhance their cognitive skills and academic excellence, and prepare them for college readiness, careers, and citizenship. The NGSS is the first document to embrace student diversity.

2.1.5. STEM Education and Cultural Diversity

Culture is a way of expressing one's life and lived experiences. A person's cultural background plays a significant role in their educational life, influencing how teachers teach and students learn [12]. Many learners enter classrooms with their holistic selves, bringing multiple intersections of race, culture, ethnicity, language, gender, dis(ability), etc.; likewise, teachers' background and beliefs inform their instructional preferences. Studies show that classroom experiences are hampered by priorities emanating from sociocultural inference, value systems, and personal experiences [9,13]. These influences are rooted in prior knowledge, mental frameworks, thought processes, opinions, mindsets, behavior, and paradigms toward a subject and determine how information is received, processed, and interpreted. According to Andrews [14], "curricular mathematics [and science] and its classroom presentation vary according to culturally established norms" (p. 13). It is essential, therefore, to recognize how these referents mediate the teaching and learning process. While examining the current pluralist society, Rodriguez [15] applauded the NGSS structure of visibility of equity and diversity in science and engineering concepts.

Before the NGSS, many scholars advocated for the structural inclusion of diverse learning that was missing in reform frameworks, for instance, Ladson-Billings and Gay's [16–20] culturally relevant/responsive education of African American students, Villegas's [19,20] Chicano bilingual students, Aikenhead's [21,22] Aboriginal cultural identity and cross-cultural

science teaching, and the work of many others who have contributed immensely to creating new frameworks like the NGSS that embrace more inclusivity in the curriculum. These scholars understood how cultural perspectives, or the lack thereof, can filter learners' interpretation of school, understanding of the content, and teacher competence and practices.

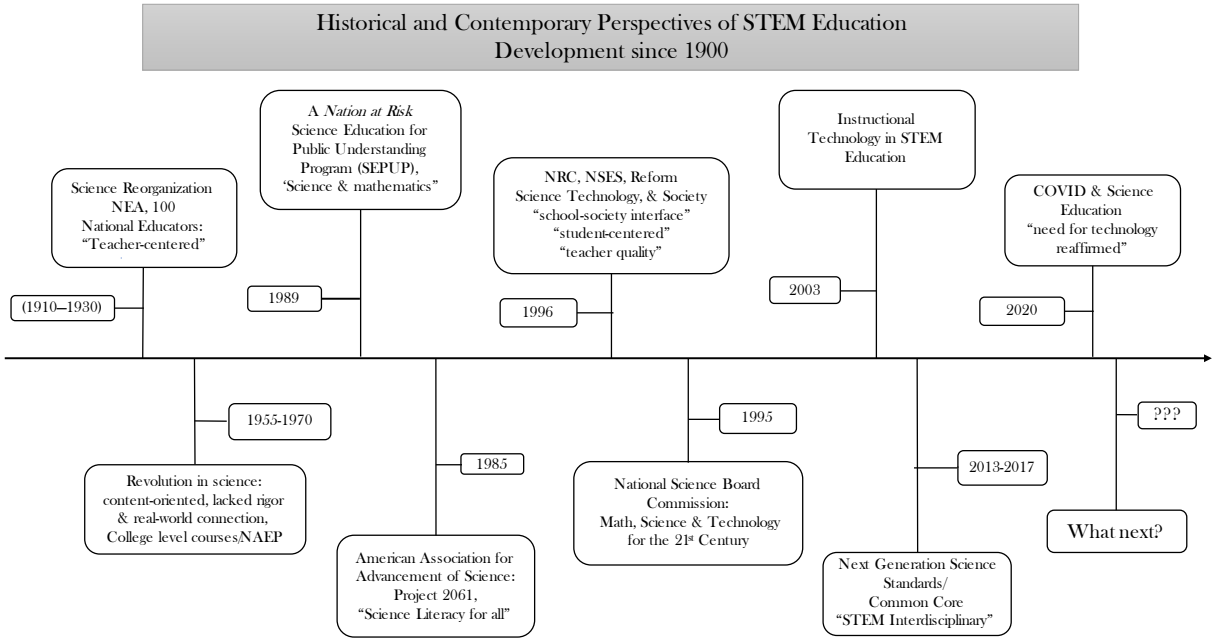

Figure 1. Comparing historical with contemporary perspectives of science education.

2.1.6. STEM Education and Cultural Competency

Teaching STEM content requires specialized skills unique to each content. Teacher education often emphasizes content expertise because teachers must be grounded in their subject. For example, in his seminal work, Shulman [1,23] noted that teachers must have expert knowledge of the content that they teach, which positions them for effectiveness. However, Dunac and Demir [24] surmised that classrooms are not just a place where students learn content but a formation zone to develop their identities [cultural or otherwise] as science [STEM] community members. Additionally, STEM education, like many content areas, is fraught with Eurocentric ideologies, which perpetuate teachers' deficit mindsets and stereotype the capabilities of non-white students. So, to ensure that teachers have content expertise, they must include cultural competency in their content knowledge, allowing for better informed instructional choice and practice.

So, what is Cultural competency? Ogodo [12] defined cultural competency as teachers' beliefs, behaviors, or skill sets used to demonstrate an understanding of learners' diversity and the ability to respond effectively to such differences in instruction. Studies indicate that teachers with cultural competency (a) possess a consciousness and sensitive disposition to embrace the richness of diversity [25–28], (b) they can create, adapt, interact, and implement responsive lessons by incorporating learners' individualities and cultural referents [12,29–32], (c) they not only recognize the Eurocentric ideology that alienates subgroups but is cognizant of the disproportionate systemic structures and inequities perpetuating the educational gap or debt between culturally, racially, and linguistically different learners [26,33,34], and (d) they affirm diversity as an asset and not a deficit by utilizing students' cultural capital in relevant ways to engage them in learning, thereby enhancing their academic achievement [17,25,31].

3. Epistemological Framing

Education is an active enterprise involving personal internalization and interpersonal interactions within sociocultural settings. Within that space, learning occurs and consists of

using the information from these social interactions to make sense of the world. To understand the knowledge acquisition process, Piaget [35,36] theorized cognitive development, describing learning as a unique experience in which learners use pre-existing schematic structures to engraft new information. Building on Piaget's description, Bruner [37] surmised that learners are predisposed to learning; therefore, instructional material and practice must structurally fit their personal experiences and background influences. Agreeing with Piaget and Bruner's presupposition of a structural learning mechanism, Vygotsky [38] introduced the social constructivism learning theory, which explains the meaning-making process where learners co-construct knowledge by processing and understanding information through real-life activities and cultural experiences. These scholars believed that learning is a system of interactions involving culture, material, language, and personal and collective real-world experiences.

Based on the constructionism lens, this study is situated in the social constructivism theory, which informs many teacher knowledge constructs. Constructivism learning theory explains how learners co-construct knowledge with more knowledgeable others, such as their teachers, peers/community of learners, family members, etc. The knowledge acquisition process within this theory encapsulates the inquiry-based, problem-based, phenomenon-based, etc., approaches used in STEM education to implement content-focused and pedagogy-rich strategies and culturally responsive teaching. The constructivism theory focuses on six core areas: (a) learner's prior knowledge, (b) active learning, (c) relevancy of information, (d) dialogic and social construction of knowledge, (e) reflective practice, and (f) contextual/authentic real-life application.

Learner's prior knowledge. Learners draw from their cultural, linguistic, or racial backgrounds to understand new information. Piaget [35] emphasized the need to build on learners' prior knowledge, noting that learning occurs when new information is situated on previous knowledge schema and experiences. This allows learners to question and reorganize their thinking to accept the new knowledge.

Active learning. One aspect of STEM content teaching that differentiates them from other subjects is the active involvement of learners in exploring and discovering new knowledge. The nature of science and mathematics requires this sense-making process through the teacher's guidance and social interaction within the community of learners.

Relevancy of information. Students are often attracted to what interests them. Therefore, the subject matter must align with learners' interests or areas of familiarity to stimulate their interests. Learners are more receptive, motivated, and likely to engage and learn when the subject interests them. Harackiewicz et al. [39] found that students' interest is a powerful motivational tool that "energizes learning, guides academic and career trajectories, and is essential to academic success" (p. 220).

Social and dialogic knowledge construction. Learning is a negotiation and social interactive process between the teacher and student, student to student, and peer collaborations within and outside the learning space. The larger community outside the classroom also influences and contributes to students' learning. These dialogic co-construction and negotiations can stimulate learners' interests and encourage information retention and mastery.

Reflective practice is a teaching approach that allows teachers and students to utilize metacognition in the process of knowing. It involves reprocessing information in a form unique to the learners' understanding. Teachers also utilize reflective practices to enhance their skills/craft. This metacognitive approach challenges new ideas by facilitating reconceptualization and engages teachers and learners in higher-order thinking as they critically assess new information and teaching and learning experiences.

Contextual/authentic real-life application. Separating school from the real world does not encourage the transfer or application of knowledge beyond the classroom. Authentic real-life connection is vital to understanding that both contexts feed off each other. McCarthy et al.'s [40] study of a Navajo reservation showed how a thoughtful process of inquiry-based teaching that considers the learner's context can bridge the gap between home and school culture.

4. Teacher Knowledge Base Constructs

Drawing from the social constructivism theory lens, the paper examines three existing teacher knowledge constructs: Shulman's [1,23] pedagogical content knowledge ([PCK], Mistra & Koehler's [41,42] technology PCK ([TPACK] and culturally competent knowledge (CCK), which encompasses Ladson-Billings' [17,26] culturally relevant pedagogy, Gay's [42,43] culturally responsive teaching, and Paris's [33] culturally sustaining pedagogy. Each form of teacher knowledge is discussed below in relation to the social constructivism learning theory.

4.1. Pedagogical Content Knowledge (PCK)

Post-Sputnik reforms centered mostly on science and mathematics education and preparing high-quality teachers. Shulman [1,23] observed the disconnect between teachers' content knowledge and the ability to effectively translate that knowledge to meet learners' needs. He conceptualized pedagogical content knowledge (PCK) by merging what teachers should know, "subject matter knowledge," and the pedagogical skills to translate that into a usable form to interest students. Shulman envisioned PCK as encompassing multiple aspects of teacher knowledge, such as subject matter knowledge, pedagogy, curricula, assessment, student characteristics, and prior knowledge. Structuring PCK to differ significantly from existing teacher knowledge requirements, Shulman maintained that pedagogical skills are necessary to transform learning in a meaningful, relevant, and responsive way for students. He believed that teachers with grounded PCK create lessons using various instructional strategies/activities that are accessible, relatable to real-life experiences, and meaningful to learners. Research supports the need for this knowledge base because it enhances teacher actions and explains why and how specific concepts are useful to the learner [43–48]. Studies also found a correlation between teachers who lack this knowledge base and limited instructional skills [43,44,46–52].

Technology Pedagogical Content Knowledge (TPACK)

The NSTA position paper [6] on Science, Technology, and Society (STS) was tested during the recent COVID-19 pandemic. This was an event that revealed how many teachers lacked instructional technology skills as the school shutdown forced everyone to transition to virtual learning spaces. Before this 2020 global event, Mistra and Koehler [42] emphasized the need for instructional technology competency to facilitate students' learning and engagement. The authors introduced the Technology, Pedagogy, and Content Knowledge (TPACK) concept, adding technology into Shulman's PCK construct. However, despite promoting classroom technology for over two decades, the COVID-19 pandemic exposed a huge digital literacy gap in instructional technology knowledge [52–54]. Researchers found limited use of instructional technology in many classrooms, resulting in learning loss during the school closures [55–57]. More troubling are findings that many new teachers have little or no technology self-efficacy to support their instructions. The need for this professional knowledge base is far-reaching, and the lack of teacher technology competency constitutes an equity issue for the under-resourced groups. The role of technology in today's world is undeniable, and as global advancements continue, teachers need this professional knowledge base to support and prepare students for current and future jobs.

4.2. Cultural Competency Knowledge (CCK)

The culturally competent teacher knowledge construct arose from another global event, increasing population and diversity. The need for cultural competency knowledge (CCK) was apparent as demographic changes occurred due to human migration. Proponents of teachers' cultural competency advocate for a knowledge base that provides a structure for racially, culturally, linguistically, and ethnically diverse learners. This knowledge base allows teachers to understand the various characteristics that learners bring to the classroom, which influence their epistemology, such as their cultural frames of

reference, beliefs, and socio-contextual experiences. According to Mensah [58], many teacher education programs fail to prepare "teachers to meet the academic needs of culturally and racially diverse students through instruction and curriculum" (p. 155). The forms of knowledge contributing to cultural competency include Ladson-Billings' [17,18] culturally relevant pedagogy, Gay's [59–62] culturally responsive teaching, and Paris's [33] culturally sustaining pedagogy, which is briefly discussed.

4.2.1. Culturally Relevant Pedagogy (CRP)

One of the early proponents of cultural competency, Ladson-Billings [18], noted the mismatch and failure of mainstream education to create a "synergistic relationship between home/community culture and school culture" (p. 467). In her seminal work, Ladson-Billings [17] advocated a culturally relevant pedagogy (CRP) that "empowers students intellectually, socially, emotionally, and politically" using their cultural referents to impart how they learn and develop skills and attitudes to grow their knowledge (p. 17). CRP embraces three domains, academic achievements, cultural competence, and sociopolitical consciousness, that provide teachers with cultural insights to structure their instruction to support diverse learners. Integrating sociopolitical consciousness, she maintained, allows teachers to create conducive learning spaces where they and their students collectively [co-construct], identify, analyze, and solve real-world problems that impact education. Studies support using CRP because classroom curricula must be culturally relevant for students whose home experiences differ from those of the Eurocentric mainstream culture and curriculum [12,61,62].

4.2.2. Culturally Responsive Teaching (CRT)

Situating a culturally responsive teaching approach on Ladson-Billings' work, scholars such as Villegas and Lucas [19] and Gay [59–62] emphasized the need for teachers to build their instruction on students' prior knowledge, cultural backgrounds, and real-life experiences. Hammond [8] described cultural responsiveness as using students' cultural identities, race, ethnicity, language, etc., as assets and a way of building trust and relationships. These scholars surmised that learning is meaningful and engaging when teachers imbed learners' frames of reference and lived experiences. Also, Johnson and Atwater [63] explained that teachers must be adequately equipped for diversified school settings to know their students and transcend their own biases about how students learn in a Eurocentric classroom. Because learners use their cultural resources, prior experiences, and funds of knowledge to interpret information, teachers must be prepared to recognize this meaning-making process.

4.2.3. Culturally Sustaining Pedagogy (CSP)

The third contributor to cultural competency is culturally sustaining pedagogy, which was expounded by Paris [33,64]. This component uses social justice and sociopolitical consciousness lenses to emphasize the need to center learners as subjects rather than objects within the shifting educational space. Paris's push for culturally sustaining pedagogy (CSP) questioned education's Eurocentric policies that perpetuate monoculturalism and monolingualism. According to Paris and Alim [64], the mainstream dominance and failure to acknowledge existing cultural pluralism in the classroom are suppressive acts that lead to systemic inequities, which disadvantage the underrepresented learners. Teachers who lack this critical pedagogy and reflective inquiry teaching may fail to reach students who are culturally, racially, and ethnically different in the classroom [12,65].

5. The Culturally Responsive Pedagogical Knowledge (CRPK) Framework

Teacher praxis and effectiveness depend mainly on the type of curriculum used to prepare them. Kereluik et al. [66] opined that America's education is failing to prepare students for the demands of the 21st century. One reason for the failure is the lack of

traction of many great ideas and teacher knowledge constructs used in isolation. While the three teacher knowledge constructs discussed in this paper have played a role in teacher preparation, they have before now been used in silos. This paper argues that integrating these crucial knowledge constructs, i.e., teacher content knowledge and pedagogy (PCK), instructional technology (TPACK), and culturally competent education (CCK), is necessary for equipping teachers holistically for the current demands of the 21st-century classroom. Figure 2 provides a graphical representation highlighting each knowledge core domain rooted in the constructivism theory.

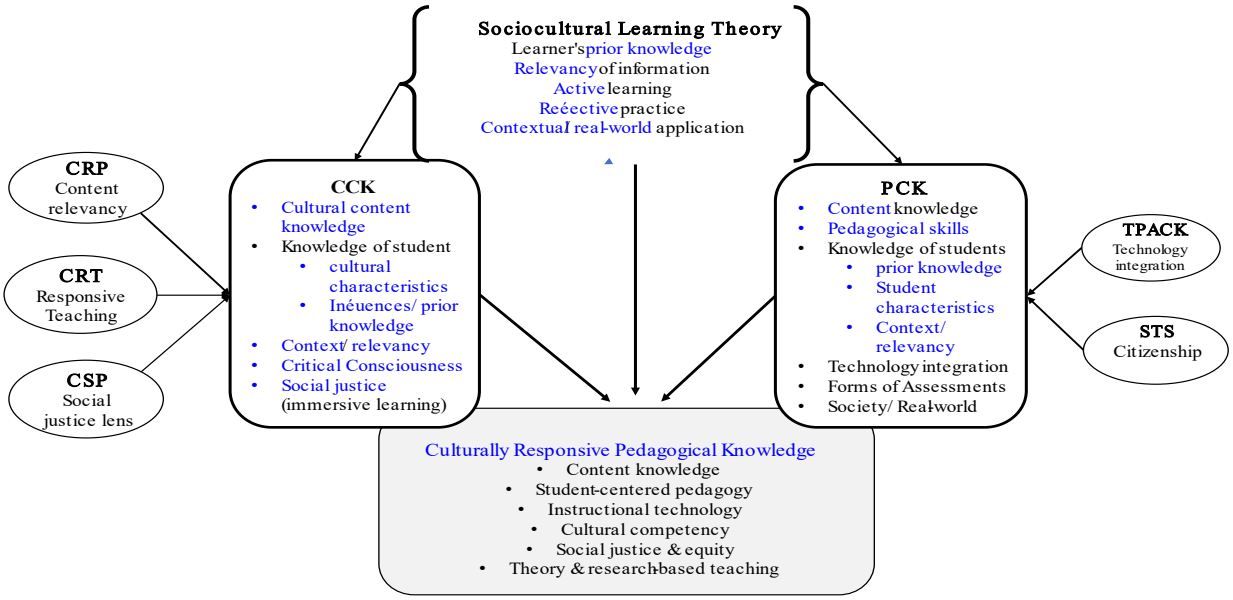

Figure 2. A visual representation of the Culturally Responsive Pedagogical Knowledge (CRPK) Framework. The highlighted texts represent core elements from the two knowledge strands contributing to the CRPK framework.

The CRPK Curriculum

Teacher praxis and effectiveness depend largely on the type of curriculum used to prepare them. The CRPK has six curricular modules that align well with the inquiry-based teaching unique to the STEM discipline. The CRPK includes six curricular areas: content, content knowledge, student-centered pedagogy, instructional technology, cultural competency, social justice and equity, reflective practice, and research and theory-based teaching, as represented in Table 1. These modules can be modified to meet the specific needs of education programs and classroom practitioners. These six domains are critical for teacher education, and they support holistic teacher practice, providing a broader and far-reaching curricular knowledge base for education programs and teachers.

Table 1. The modular focus of the CRPK curriculum.

Knowledge Areas	Explanation	Contributors
Content knowledge	This module allows teachers to be grounded in their content. When teachers are sufficiently equipped, they can make curricular and pedagogical decisions using best practices to select the material necessary to meet their instructional goals. Teachers with content expertise are likelier to produce desired learning outcomes than teachers without in-depth content knowledge.	Shulman [1,23]; Ladson-Billings [16,17,26]; Gay [20,25,42,60]; Villegas & Lucas [19].

Table 1. *Cont.*

Knowledge Areas	Explanation	Contributors
Student-centered Pedagogy	All teachers need teaching expertise, considering the various pathways to teaching. Acquiring pedagogical skills is necessary for choosing and connecting concepts across disciplines, posing questions, and assessing students' understanding. This skill is needed for meaningful co-construction of knowledge with learners.	Shulman [1,23]; Ladson-Billings [16–18,26] Gay [20,25,42].
Instructional technology	Digital competency is a critical component, as evidenced by the COVID-19 pandemic, which exposed many teachers' inability to use or implement lessons using technological tools. Teachers should be able to use technology to implement instruction more equitably for all students.	Mistra & Koehler [41]; Shulman [1,23], Berkheimer et al. [6]
Cultural competency	It is no longer sufficient to be culturally aware of diversity, as presented in many multicultural education courses. Teachers must be knowledgeable in selecting and implementing instruction that fits learners' needs and responds to their cultural influences. It emphasizes students' diversity as strengths and assets, not deficiencies.	Ladson-Billings [16,17], Gay [20]; Villegas & Lucas [19]
Social justice and equity	Cultural competency leads to active and inclusive teaching practices that promote social justice and equity advocacy. Teachers should know how to cultivate multiple perspectives, including students' voices, by exhibiting an understanding of the different learning processes for every student.	Paris [64] Paris & Alim [33,34]
Theories & research-based teaching	This module guides the process and is crucial because many teaching approaches are rooted in constructivist learning theory, and others, such as behaviorism, are used in supporting instructional practices.	Piaget [35,36]; Vygotsky [38]

6. Pedagogical Implications

Teachers can only give students what they know or serve them better when adequately prepared. When teachers are inadequately prepared to holistically serve students from all backgrounds, they often fail to reach the 85% addressed in Aikenhead's [9] humanistic approach to learning. Because students' experiences are integral to their knowledge acquisition, preparing teachers with the competency to implement culturally influenced and context-based instruction is crucial. STEM teachers need practical approaches and specialized skills to merge learners' school and home lives as presented in the science, technology, and society model. This can be challenging for under-prepared teachers with cultural deficits. Teachers who embody the integrated CRPK knowledge base can seamlessly contextualize their teaching in any setting to encompass students' familiarities and realities. This can be done in three basic ways.

6.1. Cultural Disposition

Beyond possessing the grounded content knowledge necessary for providing a variety of instructional approaches [44,46], teachers must enter the profession with a cultural disposition that is inclusive of all students. White teachers constitute about 80% of the teaching workforce in America and are informed by worldviews stemming from their backgrounds, sociocultural contexts, and academic exposures, which differ from most of their students' experiences. Having a well-informed cultural disposition allows them to know how to plan and execute their lessons and interact with their students. Ladson-

Billings [26] called this the critical consciousness needed to examine teacher identity and beliefs, i.e., their positionality and how they interfere with lesson implementation or instructional practice. Acknowledging one's positionality may lead teachers to understand learners' perspectives and utilize appropriate responses to meet their needs.

6.2. Cultural Border Crossing

Contextual immersive experience is necessary for all teachers due to teacher–student disparity due to cultural, economic, and educational background differences. Crossing the cultural border through immersive learning experiences within their students' communities can enhance their cultural competency development (see Ogodo [12] for a full description). Experiencing contextual interactions within students' communities can moderate teachers' deficit mindset and promote cultural transformation.

6.3. Social Justice Agency

Social Justice agency is a product of the border crossing experience. This element develops through contextual interactions and relationship-building across cultures (see [12,30]). Teachers who immerse themselves in the context where they teach [students' communities] can notice existing social issues that impact learners. Teachers become change agents in supporting students' academic growth and holistic development. They can advocate for students' needs more effectively, leading to greater equitable representation, especially in STEM.

6.4. Technology

Lastly, technology has become prominent in education and other spaces since the COVID-19 pandemic. The inequitable distribution caused learning loss for many during the transition to virtual education. Instructional technology can bridge learning if properly harnessed. Technologically equipped teachers are better positioned to readily access inclusive resources in this digital age to mitigate the effects of alienating certain groups from STEM education.

7. Conclusions

Like other global and national events that changed education since Sputnik (1957), the growing diverse population and recent COVID-19 pandemic call for new approaches to education. Many knowledge constructs address specific areas of teaching or learning; however, none have considered integrating these siloed pieces of teacher professional knowledge to present a holistic view of teaching and learning in diversified educational settings. The current Eurocentric structure of STEM education does not embrace learners' diversities or characteristics vis-à-vis the impact of their cultural backgrounds on their learning. Therefore, teachers must have the cultural competency for effective teaching.

STEM education can use all aspects of the CRPK described in this paper. Preparing STEM students for the 21st-century demands requires effectively translating the content into useful forms that inspire students to engage in solving real-world problems to improve their communities. Beyond content expertise and learning the act of teaching, teachers must have the cultural competency skill set and technology-based best practices. The CRPK construct presents a practical holistic curricular approach useful for STEM teacher preparation, development, and growth. Each aspect of this knowledge construct is rooted in the social constructivism learning theory, emphasizing inquiry-based practices promoted in STEM education. By integrating content, pedagogy, instructional technology, and cultural competency as fundamental elements of teacher preparation and development, this framework will promote meaningful and inclusive learning for all students.

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References

1. Shulman, L. Knowledge and Teaching: Foundations of the New Reform. *Harv. Educ. Rev.* **1987**, *57*, 1–23. [CrossRef]
2. Gardner, D.P.; National Commission on Excellence in Education. A Nation at Risk: Imperative for Educational Reform. *Elem. Sch. J.* **1983**, *84*, 113–130.
3. Breiner, J.M.; Harkness, S.S.; Johnson, C.C.; Koehler, C.M. What Is STEM? A Discussion About Conceptions of STEM in Education and Partnerships. *Sch. Sci. Math.* **2012**, *112*, 3–11. [CrossRef]
4. National Research Council. *National Science Education Standards*; The National Academies Press: Washington, DC, USA, 1996. [CrossRef]
5. Fensham, P.J. The Future Curriculum for School Science: What Can Be Learnt from the Past? *Res. Sci. Educ.* **2016**, *46*, 165–185. [CrossRef]
6. Berkheimer, G.D.; Bybee, R.W.; Donnellan, K.M.; Hurd, P.D.; Maxwell, D.E.; Peterson, R.; Pratt, H. An NSTA Position Statement: Science-Technology-Society: Science Education for the 1980s. *Iowa Sci. Teach. J.* **1983**, *20*, 11.
7. Aikenhead, G.S. The humanistic and cultural aspects of science and technology education. Presented at the International Organization for Science and Technology Education (IOSTE) Symposium, Lublin, Poland, 25–30 July 2004; Volume 11, pp. 25–30.
8. Hammond, Z.L. *Culturally Responsive Teaching and the Brain*; Corwin Press: Thousand Oaks, CA, USA, 2015.
9. Aikenhead, G.S. Humanistic school science: Research, policy, politics and classrooms. *Sci. Educ.* **2022**, *107*, 237–260. [CrossRef]
10. National Research Council. *A Framework for K-12 Science Education: Practices, Crosscutting Concepts and Core Ideas*; National Academy Press: Washington, DC, USA, 2012. [CrossRef]
11. National Research Council. *Next Generation Science Standards: For States, by States*; The National Academies Press: Washington, DC, USA, 2013. [CrossRef]
12. Ogodo, J.A. Developing STEM Teachers' Cultural Competence through an Urban Teaching Curriculum: A Cultural Border Crossing Experience. *J. Sci. Teach. Educ.* **2022**, *34*, 267–286. [CrossRef]
13. Fensham, P.J. Skepticism and trust: Two counterpoint essentials in science education for complex socio-scientific issues. *Cult. Stud. Sci. Educ.* **2014**, *9*, 649–661. [CrossRef]
14. Andrews, P. Understanding the cultural construction of school mathematics. In *Mathematical Cultures*; Lavor, B., Ed.; Springer International Publishing: Berlin/Heidelberg, Germany, 2016; pp. 9–23.
15. Rodriguez, A.J. What about a dimension of engagement, equity, and diversity practices? A critique of the next generation science standards. *J. Res. Sci. Teach.* **2015**, *52*, 1031–1051. [CrossRef]
16. Ladson-Billings, G. *The Dreamkeepers: Successful Teachers of African American Children*; Jossey-Bass Publishers: Hoboken, NJ, USA, 1994.
17. Ladson-Billings, G. But that's just good teaching! The case for culturally relevant pedagogy. *Theory Pract.* **1995**, *34*, 159–165. [CrossRef]
18. Ladson-Billings, G. Toward a Theory of Culturally Relevant Pedagogy. *Am. Educ. Res. J.* **1995**, *32*, 465–491. [CrossRef]
19. Villegas, A.M.; Lucas, T. Preparing Culturally Responsive Teachers: Rethinking. *J. Teach. Educ.* **2002**, *53*, 20–32. [CrossRef]
20. Gay, G. Preparing for Culturally Responsive Teaching. *J. Teach. Educ.* **2002**, *53*, 106–116. [CrossRef]
21. Aikenhead, G.S. Many student cross cultural borders to learn science: Implications for teaching. *Aust. Sci. Teach. J.* **1998**, *44*, 9–12.
22. Aikenhead, G.S. Cross-cultural science teaching: *Rekindling traditions* for aboriginal students. *Can. J. Sci. Math. Technol. Educ.* **2002**, *2*, 287–304. [CrossRef]
23. Shulman, L.S. Those Who Understand: Knowledge Growth in Teaching. *Educ. Res.* **1986**, *15*, 4–14. [CrossRef]
24. Dunac, P.S.; Demir, K. Negotiating White science in a racially and ethnically diverse United States. *Educ. Rev.* **2017**, *69*, 25–50. [CrossRef]
25. Gay, G. Teaching to and Through Cultural Diversity. *Curric. Inq.* **2013**, *43*, 48–70. [CrossRef]
26. Ladson-Billings, G. "Yes, but how do we do it?" Practicing culturally relevant pedagogy. In *White Teachers' Diverse Classrooms: Creating Inclusive Schools, Building on Students' Diversity, and Providing True Educational Equity*; Landsman, J.G., Lewis, C.W., Eds.; Stylus: Sterling, VA, USA, 2006; pp. 33–46.
27. Macqueen, S.E.; Reynolds, R.; Ferguson-Patrick, K. Investigating the cultural competence of preservice teachers: Comparisons and considerations. *J. Int. Soc. Stud.* **2020**, *10*, 113–137.
28. Santiago, A. Focusing on cultural competency in STEM education. *Informal Sci.* **2017**, *1*, 16.
29. Lucas, T.; Villegas, A.M. Preparing Linguistically Responsive Teachers: Laying the Foundation in Preservice Teacher Education. *Theory Pract.* **2013**, *52*, 98–109. [CrossRef]
30. Mensah, F.M. Theoretically and practically speaking, what is needed in diversity and equity in science teaching and learning? *Theory Pract.* **2013**, *52*, 66–72. [CrossRef]
31. Sleeter, C.E. An agenda to strengthen culturally responsive pedagogy. *Engl. Teach. Pract. Crit.* **2011**, *10*, 7–23.
32. Villegas, A.M.; Ciotoli, F.; Lucas, T. A Framework for Preparing Teachers for Classrooms That Are Inclusive of All Students. In *Teacher Education for the Changing Demographics of Schooling. Inclusive Learning and Educational Equity*; Florian, L., Pantić, N., Eds.; Springer: Cham, Switzerland, 2017; Volume 2. [CrossRef]
33. Paris, D. Culturally Sustaining Pedagogy: A needed change in stance, terminology, and practice. *Educ. Res.* **2012**, *41*, 93–97. [CrossRef]

34. Paris, D.; Alim, H.S. What Are We Seeking to Sustain Through Culturally Sustaining Pedagogy? A Loving Critique Forward. *Harv. Educ. Rev.* **2014**, *84*, 85–100. [CrossRef]
35. Piaget, J. *Origin of Intelligence in the Child*; Routledge and Kegan Paul: London, UK, 1936.
36. Piaget, J. Piaget's theory. In *Piaget and His School*; Springer: Berlin/Heidelberg, Germany, 1976; pp. 11–23.
37. Bruner, J.S. *The Process of Education*; Vintage: New York, NY, USA, 1966.
38. Vygotsky, L.S. *Mind in Society: The Development of Higher Psychological Processes*; Harvard University Press: Cambridge, MA, USA, 1978.
39. Harackiewicz, J.M.; Smith, J.L.; Priniski, S.J. Interest Matters: The Importance of Promoting Interest in Education. *Policy Insights Behav. Brain Sci.* **2016**, *3*, 220–227. [CrossRef] [PubMed]
40. McCarty, T.L.; Wallace, S.; Lynch, R.H.; Benally, A. Classroom Inquiry and Navajo Learning Styles: A Call for Reassessment. *Anthr. Educ. Q.* **1991**, *22*, 42–59. [CrossRef]
41. Mishra, P.; Mehta, R. What We Educators Get Wrong About 21st-Century Learning: Results of a Survey. *J. Digit. Learn. Teach. Educ.* **2017**, *33*, 6–19. [CrossRef]
42. Gay, G. *Culturally Responsive Teaching: Theory, Research, and Practice*, 2nd ed.; Teachers College Press: New York, NY, USA, 2010.
43. Ogodo, J.A. Comparing Advanced Placement Physics Teachers Experiencing Physics-Focused Professional Development. *J. Sci. Teach. Educ.* **2019**, *30*, 639–665. [CrossRef]
44. Hume, A.; Cooper, R.; Borowski, A. (Eds.) *Repositioning Pedagogical Content Knowledge in Teachers' Knowledge for Teaching Science*, 1st ed.; Springer: Singapore, 2019. [CrossRef]
45. Gess-Newsome, J. Pedagogical content knowledge. In *International Guide to Student Achievement*; Hattie, J., Anderman, E.M., Eds.; Routledge: Abingdon, UK, 2013; pp. 257–259.
46. Keller, M.M.; Neumann, K.; Fischer, H.E. The impact of physics teachers' pedagogical content knowledge and motivation on students' achievement and interest. *J. Res. Sci. Teach.* **2017**, *54*, 586–614. [CrossRef]
47. Kleickmann, T.; Richter, D.; Kunter, M.; Elsner, J.; Besser, M.; Krauss, S.; Baumert, J. Teachers' Content Knowledge and Pedagogical Content Knowledge. *J. Teach. Educ.* **2013**, *64*, 90–106. [CrossRef]
48. Sunal, C.S.; Sunal, D.W.; Ogodo, J.; Stephens, M. High school physics teaching reform: Support for professional development in the literature. In *Physics Teaching and Learning: Challenging the Paradigm*; Sunal, D., Shemwell, J., Harrell, J.W., Sunal, C., Eds.; Information Age Publisher: Charlotte, NC, USA, 2019; pp. 1–20.
49. Chan, K.; Hume, A. Towards a consensus model: Literature review of how science teachers' pedagogical content knowledge is investigated in empirical studies. In *Repositioning Pedagogical Content Knowledge in Teachers' Knowledge for Teaching Science*; Springer: Berlin/Heidelberg, Germany, 2019; pp. 3–76.
50. Roth, K.J.; Wilson, C.D.; Taylor, J.A.; Stuhlsatz, M.A.M.; Hvidsten, C. Comparing the Effects of Analysis-of-Practice and Content-Based Professional Development on Teacher and Student Outcomes in Science. *Am. Educ. Res. J.* **2019**, *56*, 1217–1253. [CrossRef]
51. Gess-Newsome, J. A model of teacher professional knowledge and skill, including PCK: Results of the thinking from the PCK Summit. In *Re-Examining Pedagogical Content Knowledge in Science Education*; Routledge: Abingdon, UK, 2015; pp. 38–52.
52. Ogodo, J.A.; Simon, M.; Morris, D.; Akubo, M. Examining K-12 Teachers' Digital Competency and Technology Self-Efficacy During COVID-19 Pandemic. *J. High. Educ. Theory Pract.* **2021**, *21*, 13–27. [CrossRef]
53. Darling-Hammond, L.; Hyler, M.E. Preparing educators for the time of COVID... and beyond. *Eur. J. Teach. Educ.* **2020**, *43*, 457–465. [CrossRef]
54. Golden, A.R.; Srisarajivakul, E.N.; Hasselle, A.J.; Pfund, R.A.; Knox, J. What was a gap is now a chasm: Remote schooling, the digital divide, and educational inequities resulting from the COVID-19 pandemic. *Curr. Opin. Psychol.* **2023**, *52*, 101632. [CrossRef] [PubMed]
55. Azevedo, J.P.; Hasan, A.; Goldemberg, D.; Geven, K.; Iqbal, S.A. Simulating the Potential Impacts of COVID-19 School Closures on Schooling and Learning Outcomes: A Set of Global Estimates. *World Bank Res. Obs.* **2021**, *36*, lkab003. [CrossRef]
56. Dorn, E.; Hancock, B.; Sarakatsannis, J.; Viruleg, E. COVID-19 and Student Learning in the United States: The Hurt Could Last a Lifetime. McKinsey & Company, 1. 2020. Available online: https://www.mckinsey.com/industries/education/our-insights/covid-19-and-student-learning-in-the-united-states-the-hurt-could-last-a-lifetime (accessed on 21 November 2022).
57. Engzell, P.; Frey, A.; Verhagen, M.D. Learning loss due to school closures during the COVID-19 pandemic. *Proc. Natl. Acad. Sci. USA* **2021**, *118*, e2022376118. [CrossRef]
58. Mensah, F.M. "Now, I See": Multicultural Science Curriculum as Transformation and Social Action. *Urban Rev.* **2022**, *54*, 155–181. [CrossRef]
59. Gay, G. The what, why, and how of culturally responsive teaching: International mandates, challenges, and opportunities. *Multicult. Educ. Rev.* **2015**, *7*, 123–139. [CrossRef]
60. Gay, G. Acting on Beliefs in Teacher Education for Cultural Diversity. *J. Teach. Educ.* **2010**, *61*, 143–152. [CrossRef]
61. Mutegi, J.W. The inadequacies of "Science for All" and the necessity and nature of a socially transformative curriculum approach for african American science education. *J. Res. Sci. Teach.* **2011**, *48*, 301–316. [CrossRef]
62. Scott, L.M.; Venegas, E.M. Linguistic hegemony today: Recommendations for eradicating language discrimination. *J. Multicult. Educ.* **2017**, *11*, 19–30. [CrossRef]

63. Johnson, N.H.; Atwater, M.M. The impact of beliefs and actions on the infusion of culturally relevant pedagogy in science teacher education. In *Multicultural Science Education*; Atwater, M., Russell, M., Butler, M., Eds.; Springer: Berlin/Heidelberg, Germany, 2014; pp. 81–102.
64. Paris, D.; Alim, S.A. *Culturally Sustaining Pedagogies Teaching and Learning for Justice in a Changing World*; Teachers College Press: New York, NY, USA, 2017.
65. Doucet, F. What Does a Culturally Sustaining Learning Climate Look Like? *Theory Pract.* **2017**, *56*, 195–204. [CrossRef]
66. Kereluik, K.; Mishra, P.; Fahnoe, C.; Terry, L. What knowledge is of most worth: Teacher knowledge for 21st-century learning. *J. Digit. Learn. Teach. Educ.* **2013**, *29*, 127–133. [CrossRef]