



A Conceptual Model for Engineering Educators in Rural Places: Critical Reflection and Engagement

THEORY

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ABSTRACT

Rural educational contexts often go under addressed in engineering education research and practice. Given the specific nuances associated with rural places and contexts, engineering education outreach should be better aligned with ongoing efforts to recognize and engage students' assets in education. This paper introduces a conceptual model that proposes tenets, or considerations, for engineering engagement in rural places. The tenets include: understand self and context rooted in a place; seek to (re)contextualize curriculum; encourage students' assets and other ways of knowing, and engage critically and hopefully. The tenets of this paper are grounded in literature from rural education, P-12 engineering education, asset-based education, and literature pertaining to the rural Appalachian context and spatial justice. Each tenet section presents some of this literature as well as questions for individual reflection to further engage with the tenets. The conceptual model presented in this provides a framework for ongoing reflection on the importance of place and how place can inform engineering education outreach and engagement. Though this paper focuses on rural contexts, the tenets used to organize the model and the associated reflection questions could prove useful to work in various contexts (e.g. suburban, urban). Ultimately, this paper encourages the recognition of how geographies impact communities and how to engage with place in P-12 engineering education settings.

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INTRODUCTION

Over the last decade, there has been an increased push to prepare students for STEM careers to grow the engineering workforce by broadening participation in engineering. It is known that many racial and ethnic groups continue to be marginalized in higher education and especially engineering, including Black or African American, Hispanic or Latinx, and American Indian or Alaskan Native students (National Academy of Engineering, 2011). Additionally, low-income and first-generation students (Smith & Lucena, 2016a, 2016b; Verdin et al., 2019, 2021), and students from rural communities have been historically marginalized in higher education and engineering (Ardoin, 2018; Carrico, 2013). Further, students at the intersections of these marginalized groups face more barriers when it comes to pursuing engineering. In engineering education research, rural identities and rural communities have not been a significant focus, and there remains a gap in rural STEM research broadly (Harris & Hodges, 2018).

To broaden participation and expand the engineering workforce, many have looked to K–12 settings to introduce students to engineering pathways early in their education to spark their interests and encourage them to pursue careers in engineering. These K–12 interventions include a variety of strategies from university outreach, robotics teams, engineering camps, and the intentional integration of engineering concepts into existing science standards (Brophy et al., 2008; Sneider & Ravel, 2021). Many of these strategies seek to provide students with opportunities to explore concepts in hands-on ways to encourage deeper engagement. This is particularly true of standards like the Next Generation Science Standards (NGSS) (National Research Council, 2013). However, it is problematic to expect that all students have equal access to these extracurricular opportunities or programs, and that all schools can integrate standards like the NGSS into their curriculum. Well-resourced schools are typically positioned to offer these opportunities to students. However, the existing structures that fund public education in the United States (Koricich et al., 2018) and the expectations placed on teachers and students by the increased demands in achievement testing (Maranto, 2015) present challenges to schools that are not as well resourced. Schools in locations experiencing economic hardships, particularly in rural and urban areas, are often at a resource disadvantage due to relying on local taxes to fund public education and the inequitable distribution of resources to these places (Koricich et al., 2018).

In rural areas in particular, schools have additional difficulties recruiting and retaining teachers and administrators (Ardoin, 2018; Avery, 2013; Zinger et al., 2020) and funding extracurricular activities (Boynton, 2014). Due to the inequitable distribution of resources to rural areas coupled with their geographic isolation, teachers have reported difficulty connecting with other teachers and gaining access to professional development opportunities and training to be able to implement standards like the NGSS (Zinger et al., 2020). Similarly, students have limited access to educational resources like gifted education, museums, and extracurriculars (Azano & Callahan, 2021; Boynton, 2014; Hartman & Kahn, 2019). The education policies and approaches that are widely implemented in the United States have been done with a broad brush—assuming that mandated curriculum and standards make all things equal. Many have argued that mandated curriculum and standards have decontextualized learning for many students, and that curriculum and standards were developed from a lens of middle-to-upper-class, White suburbia, which lacks context for many students in the education system (Gruenewald, 2003a, 2003b; Peine et al., 2020). This decontextualization has resulted in students not seeing themselves or their experiences, often deeply tied to their communities, families, and places, reflected back to them in their education (Peine et al., 2020). For rural students, this often presents itself in the form of rural life being undesirable in the current globalized world and encourages narratives that one can only succeed if they leave rural places for life elsewhere (Carr & Kefalas, 2009; Petrin et al., 2014; Shamah & MacTavish, 2018).

The purpose of this paper is to present a conceptual model informed by literature for how university-level engineering educators might engage more intentionally in rural places with greater attention to broader systemic issues impacting rural communities. For this paper, engineering educators refers specifically to those of us working in colleges and universities who might be conducting applied research in rural areas, engaging in partnerships with teachers and

students in rural schools, or doing some other type of educational outreach, service learning, or community engagement in rural places. This conceptual model presents considerations to prompt more intentional, literature-grounded, place-informed research and practice. The need for this paper has spurred out of work which focuses on K–12 engineering education in rural Appalachian places (Grohs et al., 2020). As engineering educators, recognizing specific experiences related to place (in this case, rural places) is crucial to how we think about our research and interventions. While in many cases we might seek to develop activities around topics like robotics, virtual reality, or other technologies, for example, we should not be doing so without considering the place, the people, and the broader context in which we work. This includes not only consideration for the resources people might have access to (e.g., appropriate technology) but also consideration for the lived experiences of people in those communities. This paper ties together broader bodies of literature from rural education, asset-based theories and practices, K–12 engineering education, and theories of spatial justice and place-based education to inform the conceptual model. The four tenets of the conceptual model are:

- Understand self and context rooted in place.
- Seek to (re)contextualize curriculum.
- Encourage students' assets and multiple ways of knowing.
- Engage critically and hopefully.

Recognizing some of the shortcomings of more popular engineering education outreach and educational approaches, this conceptual model and its tenets can be used to design interventions to recognize the importance of and align with the idea of place while embracing the assets of rural communities. These tenets can also inform how we might perform research in rural places and how we might engage in partnerships with educators in rural places. This paper provides important connections to research and theory in rural education while prompting additional reflection about working in rural places.

AUTHOR POSITIONALITY AND CONTEXT

Given the importance of this recent work and our relationship to the research area, addressing positionality is crucial to identifying our own biases and how we do or do not relate to this work (Hampton et al., 2021). The following sections address each author's individual positionality and our regional context that ultimately led to the work presented here.

FIRST AUTHOR

I am a white, nondisabled, queer person from Appalachia. I was trained in mechanical engineering and received a degree from a four-year institution. My positionality is informed by the privilege I experience due to being white and nondisabled in a society built on white supremacy and the marginalization I have experienced due to being queer and Appalachian. Additionally, I have always had access to education and had the support from my family to pursue an engineering degree, and I am now pursuing graduate degrees, all of which further contribute to the privileges I experience. My positionality is further informed by my experiences in undergraduate education, where I first realized that my experience with and access to engineering before college was significantly different from my peers, and rarely felt as though my identity, my experiences, and my interests in engineering were reflected throughout my education. As such, I have begun to explore this further as part of my own research. Throughout my graduate education, I have come to understand and value the importance of context and community in all aspects of research and practice.

SECOND AUTHOR

I am a white, nondisabled man who grew up mostly in Virginia and attended Virginia Tech to earn degrees in both engineering and education. While my parents did not earn university degrees, my educational pursuits were strongly influenced and supported by my parents and by my being

the youngest of four children who financially supported themselves earning degrees, including two older brothers who became engineers. These experiences have caused me to reflect on the many sociocultural factors that expand or constrain students' educational and career goals. Prior to working in engineering education, I was a faculty member in the university center for student engagement and community partnerships which strongly informs my beliefs about the responsibilities and roles university faculty should have in collaboratively addressing urgent community issues that align with their expertise and/or are influenced positively or negatively by their academic field. I have supported or led multiple collaborative applied research projects with rural schools and focused on rural youth and these experiences have further shaped my motivation for and approach to the work discussed in this article.

JOINT STATEMENT

Together, our experiences significantly shape our inquiry and synthesis in this paper. For example, we both consider ourselves to be pragmatic and seek connections to action and practice that are informed by theory and literature. In fact, we have both been engaged in prior applied work in the Appalachian region as a PI (second author) and a research assistant (first author) with varying degrees of engagement throughout the duration of the project. From this experience, we approached this work with the understanding that prior work was incomplete and needed to improve moving forward by better recognizing the Appalachian context and engaging in asset-based approaches in this context. Because of this, many examples in this paper lean on the Appalachian context as an example. This paper was also informed by work completed for the first author's dissertation milestones, which the second author advises. However, we approach this work as outsiders to P-12 education as neither of us has ever worked as an employee in a P-12 setting. Therefore, our understanding of the P-12 context is lacking an insider perspective, and we try to acknowledge the challenges related to the conceptual model presented in this paper as we perceive them as partnering educators and researchers.

UNDERSTANDING THE APPALACHIAN CONTEXT AND SPATIAL JUSTICE

Because much of our work takes place in Southwest, Appalachian Virginia, the following section describes more about the demographics and history of the region as it is informed by a lens of spatial justice. Appalachia is a region largely defined by the Appalachian Mountain Range in the Eastern United States. The region itself includes 420 counties in 13 states, and accounts for about 25.7 million people (Appalachian Regional Commission [ARC], 2021). Of the 420 counties, 82 counties have been designated as distressed, 109 as at-risk, and 218 as transitional (ARC, 2023). The remaining 14 counties have either been classified as competitive or attainment, meaning the economies are stronger in those counties (ARC, n.d.) These designations are determined by comparing Appalachian counties to national averages in metrics like three-year unemployment rates, per capita market income, and poverty rates (ARC, n.d.). In 2019, the median household income in Appalachia was \$51,916 compared to \$62,843 nationally (ARC, 2021).

As a whole, rural students are underrepresented in higher education (Ardoin, 2018). According to data from 2019 from the National Center for Education Statistics (NCES, 2021), only 24.7% of people aged 25 and older from rural areas earned a bachelor's degree or higher, compared to 37% from cities, 36.7% from suburbs, and 22.5% from towns. More specifically, Appalachian students, who are also often considered rural students, are also underrepresented in higher education and engineering. As of 2019 in Appalachia, 24.7% of the population over the age of 25 held a Bachelor's degree or more, compared to 32.1% nationally (ARC, 2021). When looking more closely at the context of Appalachian Virginia level data, 20.9% of the population over the age of 25 in Appalachian Virginia held a Bachelor's degree or more, compared to 40.6% for non-Appalachian Virginia (ARC, 2021). Of the Bachelor's degrees held by the population over the age of 25 in Appalachia, 30.9% of them are in science and engineering compared to 35.1% nationally (ARC, 2021). In Appalachian Virginia, 35.3% of the Bachelor's degrees held by the population over the age of 25 are in science and engineering compared to 40.9% of those degrees in non-Appalachian Virginia (ARC, 2021). These trends of underrepresentation in higher education and engineering

are consistent with previously conducted research focusing on Appalachian students pursuing engineering (Boynton, 2014; Carrico, 2013).

Looking at these numbers alone, however, does not provide a full picture or explanation of the Appalachian region—there is also a deeply rooted structural and historical explanation. As Peine et al. (2020) highlight, there is a history of systemic exploitation of people and resources, and expropriation of power and resources by entities outside the Appalachian region, often by extractive industries (e.g., coal mining) that have provided resources for much of the United States. The intentional and systemic expropriation and exploitation in Appalachia has led to people experiencing years of dispossession which has deeply affected the “sociocultural bedrock of [Appalachian] communities” (Peine et al., 2020, p. 45). This means that while the region provides greatly needed resources to many places, there is little to no investment of the rewards from these resources back into the communities, which enables the conditions of poverty and further exploitation. This has ultimately led to many outsiders pushing narratives around the “culture of poverty” and wield stereotypes around the “backwardness” and supposed low ambition of the people who live in Appalachia as a way to blame communities and people for their experiences (Peine et al., 2020). These stereotypes are harmful and can be challenging to overcome, especially when they have become embedded in and perpetuated by systems and structures that continue to affect the region.

This systemic dispossession and decontextualized curriculum deeply affect how rural students might see themselves and their experiences reflected back to them throughout their education. Therefore, making explicit connections to students’ places is key for students to connect their experiences with their learning, and reclaim power in their communities (Gruenewald, 2003a, 2003b; Peine et al., 2020). Having a deeper understanding of place allows for an understanding of spatial justice, defined by Biddle et al. (2019) as “the power dynamics governing [a] phenomenon [that] should be unpacked with regard to how they may or may not differ with regard to rural space” (p. 10). Geographers, like Edward Soja, have argued that the term spatial justice suggests that justice “has a consequential geography” (Soja, 2010, p. 1), meaning that justice is related to the actual geography of places. Though the term is generally used in conversations about city planning, urban spaces, and related policies, Soja (2010) argues that a spatial lens can be used to further sociological and historical understandings of our conditions which might often pertain to exploitation and oppression. Spatial justice emphasizes the importance of place when it comes to those in power, for example researchers, practitioners, and policymakers, making informed decisions about how policy and practice should or should not differ between communities (Biddle et al., 2019). In the case of Appalachia and many other rural places, this understanding of spatial justice can help bridge the historic, structural contexts of places and the current understandings of life and education.

RURAL, P-12 STEM EDUCATION

Concentrated efforts have been made to expand the engineering workforce by engaging students in engineering starting prior to college, sometimes as early as pre-school. These efforts have ranged from outreach programs, curriculum, interventions, and extracurriculars to name a few (Brophy et al., 2008; Sneider & Ravel, 2021). In tandem with these efforts, research in P-12 engineering education has also become a concentrated effort. In a recent article, Sneider and Ravel (2021) found that existing P-12 engineering education research focuses on students’ understandings, skills, and attitudes about engineering and technology, effective methods of P-12 engineering education, and the benefits of P-12 engineering education. Among the effective teaching strategies and activities, Sneider and Ravel (2021) found that extant literature emphasized a focus on engineering design, robotics, bioengineering, engineering curricula integrating throughout pre-college contexts. These contexts typically include Project Lead the Way, and extracurricular experiences including museums, outreach, camps.

However, in many rural places, these teaching strategies and activities may be difficult to implement. For example, some extracurricular experiences cost money and potentially time—

time in the form of transportation to and from school, which can be lengthy due to the distances some rural students live from their schools (Boynton, 2014). Other research has also identified issues of accessibility for students and families when it comes to museums (Hartman & Kahn, 2019), outreach programs, and summer camps (Harris & Hodges, 2018).

As previously mentioned, teacher professional development and resources are crucial to the successful implementation of engineering integration in curriculum, both to which rural teachers and schools have limited access (Harris & Hodges, 2018; Zinger et al., 2020), often due to funding or geographic distance from other schools, teachers, and resources. Additional research has focused on rural teachers' access to professional development based on funding structures put into place by educational policies like No Child Left Behind (Yettick et al., 2014) and how these policies impact smaller school districts, which are often rural. For example, Yettick et al. (2014) described that some funding from No Child Left Behind (e.g., Title II) is often determined by the number of students at one school, which generally means that smaller schools do not receive as much funding. This presents a challenge for schools who might rely on this type of funding source to provide professional development to their teachers. Paradise et al. (2022) argued for the importance of being able to work with other teachers in rural schools to build teaching engineering self-efficacy and working with community partners and industries to connect engineering to the classroom, which may be one strategy to overcome some of the challenges related to teacher professional development. Overall, this literature on teacher professional development often points to the importance of rural teachers having access to opportunities and resources to become more comfortable with integrating STEM, particularly engineering, into their classrooms.

Other research in rural P-12 engineering education often deals with college choice processes and career pathways. For example, though not necessarily STEM specific, some researchers have primarily focused on predicting the factors affecting rural Appalachian students' career choices which they found to include vocational and educational self-efficacy beliefs, college and career outcome expectations, perceived barriers, parental support and socioeconomic status (Ali & McWhirter, 2006; Ali & Saunders, 2006, 2009). Relatedly, work from Carrico (2013) and Boynton (2014) suggests that rural Appalachian students pursuing engineering are concerned about staying near family and staying local, having a stable job and income, the types of jobs available locally, perceptions of and desired outcomes for future careers, alignment between these desired outcomes and engineering careers, and the existence of supports and barriers. Worsham et al. (2021) focus primarily on rural students' college choices as it pertains to STEM, highlighting that direct-entry-to-major can be problematic for rural students, who may not have a clear understanding of what it is like to be in a college classroom or what the degree program entails. Furthermore, guidance counselors who might provide college and career support are often overstretched, and students may not have access to other college preparation programs (Worsham et al., 2021). To mitigate some of these challenges, existing research about rural students' STEM career choices consistently identifies the importance of community connections and collaborations (Carrico et al., 2019; Knutson & Del Carlo, 2018; Matusovich et al., 2017; Worsham et al., 2021). These community connections and collaborations serve as a way for students to identify potential mentors in their communities and for students to see examples of careers that exist in their communities. This is particularly important for STEM careers so students can gain access to these careers and develop an understanding of how they might pursue STEM careers.

Additional research does also specifically focus on students' experiences with STEM. For example, Nixon et al. (2021) focused on rural teens' STEM identity development through their participation as "maker-mentors" in a mobile makerspace. Students' participation as maker-mentors fostered their STEM identity development while participating in pre-college engineering experiences in their rural communities (Nixon et al., 2021). Avery and Kassam (2011) found that students in 5th and 6th grade were able to identify instances of engineering and science connections in their communities, outside of their classrooms. Gillen et al. (2017) explored rural, Appalachian 5th grade students' perceptions of engineering work using the Draw an Engineering Test (DAET) as a way to determine students' conceptions of engineering to develop culturally relevant engineering activities.

It is also important to note work focusing on rural and Indigenous communities in the P-12 space, as many Indigenous communities remain in rural areas in the U.S. (RedCorn et al., 2021). For example, Jordan et al. (2019) sought to understand more about Navajo engineers' experiences with engineering in the context of their culture and community to develop a P-12 curriculum for Navajo students to expand pathways into engineering. Furthermore, Bang and Medin (2010) focus on the need to support epistemologies held by urban and rural Indigenous students to foster better learning environments in science education. These authors, and many others, highlight important nuances about the influence of Indigenous culture on STEM education and how to support Indigenous students in their engagement in STEM.

Given this landscape of some of the existing rural, P-12 STEM education work, there are important connections to be emphasized. First, there is a need to further understand and address inequities that affect rural places. This requires consideration of historic, social, and geographic contexts in the regions we work as there are important implications related to the geographic and cultural spaces particularly for any educational context. Additionally, aligned with some of the research presented here and calls for more asset-based approaches in engineering education (e.g., Martin & Wendell, 2021), directly connecting to rural places in educational activities or curriculum is imperative.

CONCEPTUAL MODEL

The following section presents a conceptual model that can be utilized to inform engineering education researchers about how to engage in rural contexts, either in the context of research or the design of any education interventions. According to Meredith (1993), "a conceptual model is...a set of concepts, with or without propositions, used to represent or describe (but not explain) an event, object, or process." (p. 5). The conceptual model proposed in this paper seeks to describe considerations related to conducting engineering education research in rural places. This model addresses not only what we should be reflecting on as researchers but also how we might develop interventions in rural places and engage students in engineering. Therefore, this conceptual model was developed from rural education literature, critical pedagogy of place, and rural literacies. It was further inspired by previous work and projects in rural Appalachia, all of which are cited throughout the following sections. The conceptual model proposes the following four crucial tenets to consider and on which to reflect as engineering educators engage with rural places:

- Understand self and context rooted in place.
- Seek to (re)contextualize curriculum.
- Encourage students' assets and multiple ways of knowing.
- Engage critically and hopefully.

This section includes a table (Table 1) of the proposed reflection questions. Though the tenets below are presented separately, some of the literature and ideas presented do overlap.

UNDERSTAND SELF AND CONTEXT ROOTED IN PLACE

Understanding how the impact of place is related to ourselves and the contexts in which we work is incredibly important. This tenet requires us to engage more deeply with how everything is rooted in the concept of place and can be interpreted through a lens of place—including how we understand ourselves individually, how we are perceived, how we participate, and how issues present themselves in places.

When thinking about how we understand ourselves, there is some familiar language we might already use. For the field of engineering education, this often comes in the form of positionality statements. Recently, two groups of scholars in engineering education (Hampton et al., 2021; Secules et al., 2021) have emphasized the importance of researcher positionality in engineering education research. Between Secules et al. and Hampton et al., positionality can be roughly defined as how one's personal, cultural, social, or political position and identity in the world informs their research design. Secules et al. (2021) reflected on important ways positionality

TENET	PURPOSE	REFLECTION QUESTIONS
Understand self and context rooted in place	To reflect on our own identities through a lens of place, and to more deeply understand our connections to rurality.	• Did you grow up in a rural place? • How do you describe your identities (e.g. race, gender, socioeconomic status)? • Did you have access to education? • Maybe you are from the region or the community in which you are conducting research. How does this inform or affect your data collection and relationships with your participants? • What do your participants think about your research or intervention?
Seek to (re) contextualize curriculum.	To make explicit connections to local contexts to ground student learning and validate their experiences and identities.	• How do I understand this place related to my position in it? • How do the people with whom I am working understand and describe this place? • Who has expertise that could fill in gaps in my knowledge or experiences? • What do the people with whom I am working find interesting and relevant?
Encourage students' assets and other ways of knowing.	To recognize the assets of rural students, rural places, and the benefit of rural literacies.	• How do you view your own knowledge in relation to the knowledge of others? • What traditions or ways of knowing informed your own education? • What are the things you view as resources or assets that can inform students' learning? • How is what we know informed by place?
Engage critically and hopefully.	To recognize the importance of engaging students in critical, relevant issues while providing the language of possibility and hope.	• What systems can I identify around me and how are they at work? • What are the resources I can identify in this community? • What are the resources others identify? • Where are resources located in the community and how are they accessed? • What are some major industries or businesses that might impact this community? • What do the people with whom I am working identify as problems, opportunities, resources or assets in their community? • What do I (or others) want or imagine the future to be?

Table 1 Summary of tenets and reflection questions.

informs research topics, epistemology, ontology, methodology, relation to participants, and communication. Hampton et al. (2021) also argue that positionality is a critical component of research and impacts the research decisions made at every step of the research process. We must also consider our positionality as it relates to how we view rural places and how we, as researchers, are often situated and perceived in these places.

As many rural scholars have identified, researchers working with rural communities must contend with insider/outsider dynamics when dealing with their positionality (White & Corbett, 2014). While in many cases, a researcher can embed themselves in a community to build relationships and trust, this does not necessarily make them an insider. As some authors have noted, even living in a community as a researcher or being a researcher from a rural community does not necessarily guarantee full access, as people might be reluctant to participate and talk to someone they do not know well (Hamm, 2014). Furthermore, even if a researcher does have insider status, it can complicate how they might interact with participants and collect data. For example, participants might assume the researcher knows things about the community and some things will remain unspoken, or a researcher may be unable to see things differently because of their involvement in the community (Brann-Barrett, 2014; Henderson & Lennon, 2014).

When thinking about ourselves as rooted in a place—meaning how we live and participate in certain places—we must also consider how broader contexts can be viewed through place. In writing our research, we must first convey this information so that others may understand our work. As Coladarci (2007) argued in their piece regarding the quality of rural education research, being able to provide information about and descriptions of context is important for understanding exactly how a place is rural. In many instances, it is not enough to provide demographics, geographic

distance from cities, or economic factors as indicators of rurality (Biddle et al., 2019; Coladarci, 2007). In fact, it may be beneficial and necessary to describe the environment or ask the people in a community to describe their own community or their own place (Coladarci, 2007). Biddle et al. (2019) furthered this call to include explanations of how research is *critical* to rural communities. This means that power dynamics, politics and other important contexts should be included in our understanding of education research and should be used to further our understanding of rural places (Biddle et al., 2019).

In addition to writing, engaging in a context through a lens of place requires an understanding of the historical, sociocultural, political, ecological, and economic aspects of a community. As Kingsolver (2017) suggested, it is important to consider what it means to be rural in a specific place. What it means to be rural in one place is not the same as what it means to be rural in another. Rural communities often have a range of diversity that is often ignored when they are painted with a broad brush or essentialized to numbers and demographics alone. This approach is often used to paint rural places and experiences as homogenous, which might also often ignore specific histories or groups of people in rural places. Furthermore, people tend to hold many assumptions about rural places which tend to build on each other. For example, assumptions that rural places are uneducated and backward are related to assumptions about what counts as valuable knowledge and who gets to define value. The focus of placing blame on individuals removes focus from the systemic issues present in many rural communities (Eppley, 2017). On the other hand, there also runs another line of stereotypes that only seek to emphasize the idyllic or imagined rural life, for example, where there are no problems and everything is simple (Azano et al., 2020). Other stereotypes of rural places and people reinforce an assumed Whiteness (e.g., words like “White trash”; Azano et al., 2020) of rural places. However, it is certainly not the case that only White people live in rural places (Walker, 2021). Each of these assumptions and stereotypes serve to erase important social, historical, and political contexts that inform the landscape in which People of Color live. Furthermore, assumptions around rurality and Whiteness may also ignore issues pertaining to poverty, income, and education disparities experienced by People of Color in rural places, particularly in light of COVID-19 (Rowlands & Love, 2021).

As Peine et al. (2020) described in their paper about Appalachian identity and dispossession, there are unique historic implications of many places, and having this understanding is important for engaging people in their place. For example, we might understand that climate change is a global issue and a broad context that may inform our work. Viewing climate change through a lens of place can help us understand more about climate change as a local issue that is impacting the systems and people in a place. For example, climate change and energy production may be linked because many communities throughout Appalachia might have relied or may still rely on coal mining which likely affects how people might feel about renewable energy alternatives, regardless of if those feelings are generally positive or not. Therefore, recognizing this context can inform how we might develop activities or make connections to energy production. Without this lens of place, it can be hard to understand what engineering topics or approaches might be relevant to our work. Additionally, using a lens of place can help dispel perceptions that all rural places and people are the same—it is crucial to recognize that there is not a singular rural experience.

It is often the case that we might reflect on our positionalities as it pertains to our methods and practices, for example, and the view that researchers are an instrument in data collection or reflect on how our identities inform what we study or how we engage with communities. Additionally, we often address broad contexts in our work, connecting our activities, outreach, and engagement to complex, global issues. Doing these things through a lens of place can only serve to enrich our understanding of ourselves and broad contexts, and is necessary to achieve a deeper understanding of engineering education work in rural places.

SEEK TO (RE)CONTEXTUALIZE CURRICULUM

After understanding more about context and self is shaped by places, it can be easier for us to understand how we might leverage contexts to (re)contextualize engineering curriculum and learning. The term (re)contextualize refers to the reintroduction of local or relevant contexts to

curriculum, which many scholars and educators argue has been decontextualized. According to Gruenewald (2003a), “current educational discourses seek to standardize the experience of students from diverse geographical and cultural places so that they may compete in a global economy” (p. 7). Gruenewald ultimately argues that this goal of standardization is harmful to learning, and, though Gruenewald’s argument was presented almost two decades ago, standardized testing and learning outcomes have not gone away and we still rely heavily on other quantifiable school metrics.

(Re)contextualizing engineering education is important so that students might engage in something with which they are already familiar, which can lead to the validation of their own knowledge and experiences. Many scholars have presented different ways in which students’ contexts and experiences can be leveraged in education. Critical pedagogues, such as Freire (1968), have argued that education should engage students in their own worlds by focusing on problems related to their own lives. In later writing, Freire asked, “why not establish an ‘intimate’ connection between knowledge considered basic to any school curriculum and knowledge that is the fruit of the lived experience of the students as individuals?” (1996, p. 36). Ladson-Billings (1995a), in presenting the tenets of culturally relevant teaching, suggested using students’ culture as the vehicle for learning which can mean using music to engage students or engaging students’ family members in classrooms as the experts who can teach students. These approaches to pedagogy all argue for grounding educational experiences in something with which students are familiar, but many approaches to education filter knowledge and seek to standardize student learning and experiences which has significant unintended consequences.

In rural contexts, one way to (re)contextualize curriculum is through the use of place (Gruenewald, 2003a, 2003b; Smith, 2002). One approach to incorporate place into education is through place-based education. Place-based education often focuses on engaging students with the world around them through hands-on and experiential learning activities that focus on local landscapes and environments by placing education outside the walls of a school (Avery, 2013; Smith, 2002). By leaning on place in education, examples can be made relevant to the students because they can look around their community and make connections. Furthermore, Smith (2002) suggests that it can be important to engage students in problems in their immediate contexts which encourages real-world problem solving and shows them local occupations that might also engage with problems or opportunities in their communities. Critical pedagogy of place (Gruenewald, 2003a, 2003b) furthers the idea of place-based education by embracing the connection between classroom and culture in a local context. Gruenewald (2003a) argues that critical pedagogy of place seeks to link “school and place-based experience to the larger landscape of cultural and ecological politics” (p. 9) through the two related objectives to reinhabit and decolonize. In this case, reinhabit refers to learning to live in a place that has been disrupted and decolonize refers to recognizing that a disruption has occurred and addressing the causes of that disruption. Gruenewald (2003b) identifies places as being pedagogical through perceptual, sociological, ideological, political, and ecological dimensions, which can be used to think about the interconnectedness of systems and aspects of socially constructed places.

Some existing engineering education research suggests that it is crucial to use locally relevant engineering examples to spark and sustain students’ interests in engineering. As previously stated, findings from focusing on Appalachian students’ career pathways, suggest that these students desire to stay local, have a stable job and income, work that does not require physical labor, work that has variety, and work that helps others (Boynton 2014; Carrico, 2013). However, as Carrico et al. (2019) point out, the local economic situation presents both real and perceived tensions when it comes to students’ desire to stay local, as many Appalachian counties are at-risk or at a transitional stage of economic development. To mitigate this, connecting students to STEM professionals has been shown to have an influence over students’ career decisions and help spark and sustain students’ interests in engineering (Boynton, 2014; Carrico, 2013; Matusovich et al., 2017). Therefore, connecting students to engineers in local industries is one way to introduce students to locally relevant examples of engineering. Bringing these engineers into classrooms to serve as content experts can also serve as a visible connection to engineering happening in

students' communities (de-identified citation). Other examples might include asking students to develop an activity that would be relevant to them in their places or encouraging students to explore more about their place. Community members can also be engaged in activities to provide more local context. Another example of other work being done to (re)contextualize engineering in engineering education include projects like EPICS that seek to connect engineering with real-world examples for K–12 spaces by partnering with teachers to implement relevant curriculum (EPICS, n.d.). Though these ongoing projects are not always in rural spaces, they can serve as examples of what it means to (re)contextualize learning for students.

ENCOURAGE STUDENT ASSETS AND MULTIPLE WAYS OF KNOWING

Aligned with many of the frameworks and calls to shift away from deficit-based discussions of people in engineering education research, this tenet seeks to encourage the identification and recognition of rural students' assets and multiple ways of knowing. Moving to a focus on students' assets broadens what is valued in engineering education (Martin & Wendell, 2021). Some of these asset-based approaches are informed by bodies of literature around community cultural wealth (Yosso, 2005), culturally relevant and culturally sustaining pedagogy (Ladson-Billings, 1995a; Paris, 2012), and funds of knowledge (Moll et al., 1992), for example. Though some of these theories and approaches are mentioned here, please note this is not an exhaustive list. In the subsections that follow, we briefly introduce foundational work from these approaches before synthesizing across them in consideration of our aims to highlight asset-based practices for rural education.

Culturally Relevant and Culturally Sustaining Pedagogy

Culturally relevant pedagogy spurred from work by Ladson-Billings (1995a, 1995b) where they studied how teachers taught African American students and demonstrated pedagogical excellence. This ultimately resulted in Ladson-Billings proposing three tenets of culturally relevant pedagogy: academic success, cultural competence, and critical consciousness (1995a, 1995b). Culturally relevant pedagogy is a departure from the deficit views and ideologies, particularly those held about Students of Color, to improve pedagogical practices that improve educational experiences for those students. In a later response, Ladson-Billings (2014) suggested that the third tenet, critical consciousness, is often dulled or lost entirely in culturally relevant teaching practices. Ladson-Billings argued that this allows many teaching practices to fall into the same patterns that reinforce deficit-approaches and ideologies in classrooms. Furthermore, Ladson-Billings (2014) addressed the idea of culturally sustaining pedagogy presented by Paris (2012). Paris (2012) presented culturally sustaining pedagogy in a critique of the word “relevant,” arguing that it does not go far enough to ensure the value and maintenance of an “increasingly multiethnic and multilingual society” (p. 94). Paris (2012) therefore offered culturally sustaining pedagogy as a pedagogy to “perpetuate and foster—to sustain—linguistic, literate, and cultural pluralism as a part of the democratic project of schooling” (p. 95). Culturally sustaining pedagogy emphasizes the importance of students, particularly students of color, maintaining connections to their language, culture and literacy.

Funds of Knowledge

Funds of knowledge was developed from an ethnographic study in which teachers and researchers collaborated in research with Mexican-American students to explore the knowledge they bring with them into the classroom (Moll et al., 1992). Moll et al. (1992) defined funds of knowledge as “historically accumulated and culturally developed bodies of knowledge and skills essential for household or individual functioning and well-being” (p. 133), which can include agriculture and mining, economics, business, household management, material and scientific knowledge, and religion. Moll et al. (1992) suggested that the recognition and use of funds of knowledge contrasts with typical classroom practices, which often “seem encapsulated, if not isolated, from the social worlds and resources of the community” (p. 134). Furthermore, Moll et al. (1992) argued that viewing households as a source of knowledge also challenges the perceptions of working-class families as socially disorganized and intellectually deficient.

Community Cultural Wealth

Yosso (2005) defined community cultural wealth to recognize various forms of capital present in Communities of Color which was necessary to address deficit narratives about communities of color which were often argued to be lacking in cultural capital or wealth based on definitions of capital from other scholars. Yosso (2005) identified six forms of capital in this model (aspirational, familial, social, navigational, resistant, and linguistic), which ultimately challenge dominant epistemologies and narratives around social mobility and the reproduction of hierarchical society, which are primarily based on the experiences of middle- to upper-class, White people. Research in engineering education has highlighted the importance of familial capital as Black students pursue engineering (Tolbert Smith, 2022; Tolbert Smith et al., 2022), and further confirmed that the forms of capital defined by Yosso (2005) can overlap and be dynamic over time (Samuelson & Litzler, 2016; Sellers et al., 2022).

Ways of Knowing

Other asset-based work specifically focuses on epistemologies, or ways of knowing, which are also relevant to this tenet. Aikenhead (2001) argued that there are often differences between science and social contexts of learning or using science and students' lived experiences, particularly for Indigenous students in the case of their research. Aikenhead (2001) argued, students, therefore, may have to cross the border from their lives and daily experiences into school science which is a cross-cultural event that can cause cognitive conflicts and conflicts between many students' identities. Bang and Medin (2010) worked with Indigenous students and suggested that this border crossing between epistemologies should not lead students directly into Western science culture but rather enable students to mobilize intellectual resources they develop in their everyday lives. Further, Bang and Medin (2010) suggest that students' epistemologies are often thought of as incomplete and require adjusting to become aligned with Western epistemology, which is to say that other forms of knowledge are often not valued in school settings.

Connecting Asset-based Approaches to Rural Literacies

What these theories and approaches ultimately do is recognize the assets students possess, often informed by their existing knowledge, experiences, and values they have learned from their own families and communities with the goal of utilizing these in the classroom to enhance student learning and educational experiences. While these approaches and theories can and should be used in rural contexts where appropriate, especially approaches informed by funds of knowledge which was developed in a rural place (Moll et al., 1992), there remains a need to identify the specifics of rural contexts in these approaches. As engineering educators who may work in rural settings, it is crucial to be intentional about engaging students in their rural contexts and places to recognize and value their assets while leveraging appropriate literature to do so. Rural literacy is one assets-based theory that connects many of the aspects of the assets-based theories and approaches presented in this section.

Rural literacies theory expands on some of these assets and focuses on the way rural students might read, understand, and interact with the world around them. Literacies have been defined as "a complex social practice in which language, including signs, symbols, gestures, texts, and actions, is used to mediate and produce culture" (Edmondson, 2003, p. 10). These literacies are connected to social and cultural conditions which help us make meaning or make sense of the world around us. Rural literacies are further defined as literate behaviors with the social purpose of sustaining rural communities (Donehower, 2021; Donehower et al., 2007). Rural literacies offer a way for people to engage with the world around them in a way that makes sense to them. Edmondson (2003) views rural literacy as something that needs coupled with critical engagement of the signs, symbols, and texts of society to encourage open dialogue as a means to sustain rural communities as best defined by the communities themselves. According to Donehower (2021), sustaining rural communities can relate to psychological, ecological, educational, technological, and economic factors in rural places (Donehower, 2021). Engaging in dialogue around these

spaces in rural communities therefore allows people to engage with their own literacy of their own place or engage their own ways of knowing as it pertains to place.

Corbett and Donehower (2017) further argue that rural literacies are related to place-making, and that the concept of rural literacies contradicts views of rural places as “deficit spaces of inadequate educational productivity” (p. 9). Rural students might have specific knowledge that can be drawn on in education, particularly as we attempt to (re)contextualize education using students’ lived experiences. For engineering educators in rural places, recognizing and understanding rural literacy as an asset or way of knowing is crucial, and can expand our understanding of assets-based theories and their application in rural places. If we have never engaged in rural places, we might bring our own assumptions of the place or what we view as knowledge. Rural literacies challenge the assumptions we might have about rural places and the knowledge held in these places. Understanding rural literacies as a way of knowing can also help us broaden our understanding of how engineering exists in different contexts, and what “counts” as engineering. Encouraging rural literacy can engage students’ knowledge of their communities and how they make sense of the world around them.

ENGAGE CRITICALLY AND HOPEFULLY

The final tenet of this conceptual model deals with the development of critical consciousness, both in ourselves as engineering educators and the students with whom we may work. This final tenet is incredibly important to engaging in rural contexts. We do note that this tenet is also a tenet of culturally relevant teaching (Ladson-Billings, 1995a) and has been discussed by other authors of critical pedagogy such as Giroux (1992) and Freire (1968) and is therefore not unique on its own but should be acknowledged as a key challenge we feel is important and is something with which we (the authors) are grappling.

Freire (1968) made an argument for problem-posing education as opposed to the banking-method of education, which he described as being as a method that relies on students only engaging with what they are told to memorize and recite as dictated by the teacher in the position of power. Instead, Freire presented problem-posing education that allows for students to become producers of knowledge by deeply engaging with and critiquing the world around them, exploring and questioning their own realities. Freire referred to this development of critical consciousness as conscientization or “conscientização.” This development of critical consciousness requires intention and engagement on part of the facilitator, teacher, or instructor, and must be done in tandem with students. However, in many contexts, raising critical consciousness can be difficult. In fact, Ladson-Billings (2014), in a reflection on the use of culturally relevant pedagogy, noted that this final tenet of the original approach has largely been lost in implementation. Ladson-Billings (2014) suggests that few teachers have pushed students to consider critical perspectives of their realities and those practices that directly impact them and their communities. Similarly, Azano (2011) utilized a lens of critical pedagogy of place to understand an English teacher’s place-based instruction. Azano (2011) found that while the teacher engaged in place with references to the larger community, culture of the rural town, and texts that were relevant to the students’ lives, the teacher did not engage students’ critical lens or critical consciousness to talk further about the challenges the students and community faced. A critical lens allows students to confront complicated aspects of their communities with the aim of developing a more nuanced understanding of their place (Azano, 2011). While it is imperative to focus on the good things—what students bring with them as assets, what the community can offer, and the knowledge that already exists in places—a critical consciousness approach that embraces a tension of both critique and possibility can further strengthen students’ understanding of their world and current realities.

Giroux (1992) describes this tension directly and argues that while focusing on real problems and situations is crucial, critical approaches must provide the language of both critique and possibility to provide hope for future action. A critical pedagogy provides critique around cultural production and the manifestation of unequal power relations, particularly in educational contexts (Giroux, 1992). Along with this, however, critical pedagogy must also seek what is possible, beyond the

critique, so as not to continue to reproduce problems. As such, critical pedagogies of place, which was previously discussed, encourages teachers and students to become involved in the well-being of their places. Gruenewald (2003a) argues that critical pedagogies of place combine place-based education with a specific focus on situations people face, which have spatial, geographical, and contextual dimensions. Therefore, critical pedagogies of place challenge people to reflect on their own situations “in a way that explores the complex interrelationships between cultural and ecological environments” (Gruenewald, 2003a, p. 6). Gruenewald (2003a) also argues that critical pedagogy of place should engage students in action to address issues of justice (or injustice). In educational contexts, critical pedagogy of place readies learners to engage with complex ecological themes and prepare them to engage and participate in their communities. Holding the tension between critique and possibility offers opportunities for growth and for students to feel in control of their present and future.

While Patterson et al. (2021) further noted that engaging students in critical consciousness development can help them recognize privilege and marginalization as it pertains to various systems of oppression, there are sometimes challenges with encouraging it. The classroom environments in which critical consciousness can be engaged, however, must be open environments in which these discussions are welcome (Patterson et al., 2021). However, this openness is often uncommon, typically out of a desire to avoid conflict in the classroom or conflict from outsiders (Patterson et al., 2021). In some states, now, engaging critical consciousness has become increasingly difficult to address in a variety of different contexts. For example, the governor of Virginia set up a tip line for parents to report teachers who approach “divisive subjects” like critical race theory (Ankel, 2022). Additionally, many other states have proposed “Don’t Say Gay” bills which seek to ban schools from discussing topics of gender identity and sexual orientation (Jones & Franklin, 2022). Though there has been significant pushback against these practices, they are still indicative of the challenges pertaining to this specific tenet. In many ways, these bills and tip lines, and the culture surrounding them have created unsafe environments for both students and teachers to discuss difficult yet important issues.

For engineering education in rural places, acknowledging this final tenet related to critical consciousness remains important. For example, engineering is not blameless in the exploitative practices related to the extraction of resources for energy production (e.g., coal mining), to the pollution of land, air and water, and to the decisions made about resources and their distribution across all geographies (e.g., city planning). If we aim to engage students in engineering, in some cases recognizing that engineering has created or contributed to problems, particularly in rural communities, is imperative and offers a chance to allow students to consider the futures of their places. Additionally, understanding and acknowledging these contexts, as well as other socio-political realities, in what we do can be important for engaging students in their lived experiences and realities. Encouraging students to ask why things in their community are the way they are can engage them more deeply in their places and allow them to engage in strategies to address problems or opportunities they identify. Finally, we must also recognize that allowing students to explore and learn on their own, that they have expert knowledge about their communities informed by their lived experiences, and that they can influence learning is a crucial piece of this tenet. We must allow opportunities for students to be the teachers and we must be willing to learn from them.

REFLECTING ON THE TENETS

As a part of the process of engaging with this conceptual model, a list of reflection questions was developed to help facilitate how the conceptual model might be used by engineering educators to more intentionally design and engage with rural places and people. The questions presented in Table 1 relate to each tenet, and while not an exhaustive list of everything that could be asked, provide a starting point for thinking about how the tenets relate to engaging in rural places.

It is important to further consider how we as engineering educators can engage students in ways that recognize local contexts, and student and community assets while allowing them to grapple with important real-world, local issues, particularly in rural places. Encouraging students to engage in these contexts and ask questions contributes to the development of their critical consciousness and offers an opportunity for connections to issues in students' places while providing space for them to imagine new possibilities for their communities. For example, there are a number of real-world, rural examples that can spark conversation and thought from students related to engineering: due to unprecedented heavy rain during, much of eastern Kentucky has dealt with significant flash flooding due to issues of climate change and the impacts of coal mining on the reduction of topsoil and forest in the region (Boyer & Myers, 2021; Myers, 2022; US Department of Commerce, 2021). Another recent example is that of the train derailment and subsequent hazardous chemical spill in East Palestine, Ohio that has impacted many aspects of residents' lives (Sullivan, 2023). These examples can be analyzed and discussed in engineering contexts that can engage students' critique of current realities. In talking about these problems, it is also crucial to recognize the assets of the communities affected and the current resources in those communities, particularly as students are encouraged to use their own knowledge and lived experiences to think about these problems. Navigating this balance pedagogically is no doubt challenging as it can be easy to unintentionally fall into a deficit-based approach when one is consistently highlighting problems. However, we note that a primary danger of deficit-based thinking is when it places blame or cause of problems on the individuals or groups that experience them, or even worse reduces those people to be unidimensionally synonymous with the problem itself (e.g., "the homeless"). Persistent careful illumination of the systemic forces that shape felt problems in communities need not inherently become deficit-based thinking but can open possibilities as the act of problematizing an issue can be empowering as individuals recognize the influence of myriad micro-, meso-, macro-, and exo-system factors that comprise the issue.

Furthermore, we argue that there are many contexts or approaches to developing activities that align well with this model. For example, activities that might engage students in systems thinking would align well with these tenets. Activities developed around systems thinking would require not only us to reflect on our understanding of how various systems work together, but also how students perceive and understand systems, and how they might contribute to and affect their places. A useful framework for systems thinking comes from Grohs et al. (2018), which describes how the problem definition, perspectives of the problem, and time (history and future) of the problem can be used to engage in systems thinking. A study from Nazar et al. (2019) explores how one African American student engaged in an engineering design project focused on community and place. Though this study does not take place in a rural community, the activity the student engaged in and the principles the student demonstrated align well with the tenets of the proposed conceptual model in that it focused on place, student and community assets, and critical examination of the issues in the students' community. Additionally, work from Jordan et al. (2021) described a year-long activity in which Latinx students engaged in identifying problems and developing solutions around energy systems in their own communities. Again, though not explicitly a rural education focused study, this type of activity and engagement aligns well with the proposed conceptual model.

The considerations presented in this model may also be particularly important for land grant colleges and universities. According to a report from the National Congress of State Legislatures (Boggs, 2019), there are a total of 381 rural postsecondary institutions (including 218 community and technical colleges). While some of these institutions are not necessarily situated in rural areas—either due to initial land allotment or development around the institutions—many are in or border rural places, and still have wide reach throughout their respective states through extension and research.

Though this paper primarily focuses on rural places and leans heavily on the Appalachian context, the tenets presented in this model can be used in other contexts and geographies. The issues

experienced in rural places are generally issues experienced everywhere to varying degrees. Climate change, food supply, education, transportation, and healthcare (to name a few) are things with which we must all grapple, regardless of our places. That is to say, the issues rural places deal with are often similar to the issues in all places though they may look different or need different approaches due to the nuances of geography, population, culture, and other contextual factors. All of these things should be considered in the various contexts engineering educators seek to work or engage with communities.

CONCLUSION

Rural places often go ignored, are not very well understood, and are rarely studied explicitly in engineering education research. There are important nuances for us as engineering educators to understand when we engage in rural places, which we may not immediately recognize because of the perceptions and images we hold of what it means to be rural. When we miss these nuances, we miss opportunities to fully engage students in meaningful and relevant ways. Therefore, the purpose of this paper is to argue for the (re)contextualization of engineering in rural K–12 spaces through the presentation of a conceptual model informed by various bodies of literature including asset-based theories and approaches, rural P–12 STEM education, spatial justice, and critical pedagogy. The conceptual model presented here provides a way to reflect, as engineering educators, on our own positions and perspectives as we engage in rural places. Additionally, this conceptual model can be used to think about our work and can inform interventions and activities we develop in rural contexts.

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The authors have no competing interests to declare.

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