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Author	Khalid, Muhammad Talal;Appiah, Listowell;Witmer, Ann-Perry
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# Contextual Inquiry: Seven Guideposts of Investigating a Community's Context

Muhammad Talal Khalid<sup>1</sup>, Listowell Appiah<sup>1</sup> and Ann-Perry Witmer<sup>2</sup>

<sup>1</sup>Department of Electrical and Computer Engineering, University of Illinois Urbana-Champaign, USA.

[mkhalid4@illinois.edu](mailto:mkhalid4@illinois.edu)

<sup>2</sup>Carle Illinois College of Medicine, University of Illinois Urbana-Champaign, United States

## Abstract

This article presents a practical model to deepen engineers' understanding of contextual implementation of technological interventions. It starts with underscoring the critical importance of community's context for sustainable deployment of technological interventions and introduces the Contextual Engineering (*CE*) approach as an alternative to traditional engineering methods. It then highlights a key area for improvement of the *CE* framework by providing guidance on how to more rigorously identify the intersection between community context and technological interventions. The article proposes seven guideposts that engineers can use to begin forming a comprehensive understanding of the technology-context relationship including: (i) productive use in context, (ii) interoperability with existing systems, (iii) alignment with strategic objectives, (iv) compatibility with the physical environment, (v) attitude towards learning, (vi) cultural fit, and (vii) confidence in technological interventions. These guideposts are not intended to be a rigid checklist to follow, but rather flexible directives that practitioners can revisit and adapt as they progress in their journey of contextual inquiry.

## 1 Introduction

The integration of a community's unique needs and distinct conditions, that is, its context, in the design and implementation of technological interventions is essential to ensure sustainable outcomes (Chattopadhyay et al., 2021). Recent studies have shown that technological interventions that closely align with the needs and priorities of a community, by incorporating the broader sociocultural, institutional, and environmental conditions in which they are carried out, tend to be more successful (Bengo & Arena, 2013; London & Hart, 2004). This emphasizes that assimilating the client-community's context is just as important as assessing the techno-economic feasibility of these interventions (Jagtap, 2019; Kilgore et al., 2007). To this end, various engineering approaches have been proposed in the literature (e.g., (Bengo & Arena, 2013; Nieuwsma, 2015)).

Of particular relevance is the emerging field of Contextual Engineering (*CE*) (A. P. Witmer, 2018), introduced as an alternative to the traditional engineering practice, that emphasizes the importance of local context in the design and execution of technological interventions. *CE* transcends the conventional paradigm of "designing for" communities to "designing with" communities and recognizes the client-community as an active partner with unique insights and capacities rather than passive recipients of externally imposed interventions. It contends that instead of starting the technological intervention process with a checklist of technical requirements, engineering practitioners must begin by asking: 'What matters to the client-community and how can we collaboratively create solutions that align with community values?' (A. P. Witmer, 2022).

Contextual explorations in *CE* are aided by a structured three-step 3-4-5 framework that engineering practitioners can follow to develop a more holistic understanding of the client community and its context. However, to further strengthen the effectiveness of this framework, there is a crucial need to engage in ongoing discussions to refine our understanding of what constitutes high-quality information that can assist in exploring the technology-context intricacies, and how to ensure that engineering practitioners have practical tools to guide their work in diverse and complex community settings.

To that end, this paper presents a seven-point conceptualization, which is distinctive and potentially thought-provoking. Each guidepost can be approached through different methods and techniques, or a combination thereof, depending on the specific engineering practitioner, setting, and project. The main motivation for developing this conceptualization is pedagogical, as it seeks to guide engineering practitioners in identifying and collecting the high-quality data necessary for effective contextual inquiry that can guide sustainable implementation of technological interventions in a specific community. Beyond offering a concise pedagogical tool, this conceptualization also aims to foster greater appreciation for *CE* among engineering practitioners who may not have been exposed to its intricacies.

The rest of this paper is structured as follows: In Section 2, the contextual engineering approach is summarized. Section 3 explores the seven key markers for contextual inquiry. The paper concludes in Section 4.

## **2 Introduction to Contextual Engineering**

Contextual Engineering (*CE*), initially formulated as an alternative to traditional engineering decision-making in rural, non-industrialized communities, is increasingly gaining significance in industrialized settings (Robbennolt & Witmer, 2023). This approach represents a significant shift in engineering practice by emphasizing the importance of local context as a foundational element in technical decisions. The formal definition of *CE* is as follows (A. P. Witmer, 2020):

“The creative application of scientific and mathematical methods, societal understanding, and place-based knowledge to address physical needs in a way that serves the user while recognizing the influences of stakeholder motivations, capabilities, and values.”

Thus, the three key objectives of a contextual engineer are to: (i) understand the existing physical needs in a community that can be addressed through a technological intervention; (ii) investigate the motivations, capabilities, and values that shape these needs for various stakeholders<sup>1</sup>; and (iii) faithfully integrate this place-based knowledge and societal understanding into the existing mathematical and scientific models when making technical decisions.

To facilitate the achievement of these objectives, *CE* employs descriptive context investigation strategies, referred to as the *CE* 3-4-5 framework, that foster deeper connections between engineers and the communities they serve (A.-P. Witmer, 2022). The first step applies a model of three perception levels, challenging practitioners to deeply introspect their motivations and critically examine the unconscious biases that may shape how they perceive and interact with the community. The second step guides the practitioner in ascending from the lowest to the highest level of perception about the client community. In this step, the four quadrants of contextual inquiry are used to explore and describe the variety of conditions in the community. Finally, the last step evaluates the relative importance of five key contextual influences on the technical appropriateness of the implementation of engineering projects in the client community. Together, these steps allow engineering practitioners to ensure that their designs are not only technically sound but also deeply aligned with the specific context and needs of the client-community.

While *CE* provides engineering practitioners with various tools to understand the overall community context, engineering practitioners are often more interested in examining how a technological intervention will influence or be influenced by the conditions in the community. To better understand this, consider Figure 1. While in its present form the *CE* framework helps practitioners gain deeper insights into the overall circle representing the community context, it can further be strengthened by providing additional guidance on investigating the crucial region of interest, i.e., the area where circles representing the technological intervention and the community context overlap. To this end, this work introduces seven key

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<sup>1</sup> In this work, stakeholders are defined as entities that influence or are impacted by the technological intervention.

dimensions of technological interventions as they relate to the community context to help engineering practitioners navigate their investigations in a structured manner.

### 3 Seven Guideposts of Contextual Inquiry:

The heart of this paper presents seven guideposts to investigate how technology and community context intersect. These markers are proposed to guide engineering practitioners in directions where data collection can enable better understanding of contextual underpinnings of a technological intervention in a given community.

Several demonstrative and thought-inducing questions accompany the guidepost description presented in this section. However, it must be acknowledged that these questions are only intended to serve as flexible directives for practitioners to embark on their journey of contextual inquiry and may need to be revisited and adapted as the understanding of the community context evolves.

Indeed, the guideposts presented in this study pose no restriction on the data collection methods that can be utilized by the engineering practitioners and the issue of “how” to collect data to explore the community’s context remains at the practitioner’s discretion. As such, engineering practitioners can use these guideposts to design stakeholder interview questions, formulate keyword search strings for literature review, develop focus group discussion topics, or conduct ethnographic observations that aim to capture technology-context intersection in the community.

#### 3.1 Productive Use in Context

While there is no universally accepted definition of productive use, some researchers broadly describe it as the use of technological interventions for activities that contribute to social and economic development (Cabraal et al., 2005; Chattopadhyay et al., 2024; Terrapon-Pfaff et al., 2018). Productive use in context, then, is a natural extension of this definition in that it serves to ensure that productive use of technological interventions is not defined and measured according to some predetermined set of objectives established by the engineering practitioner from their domain experience elsewhere, but is instead primarily shaped by the needs and desires of stakeholders that the technological intervention is intended to serve.

Thus, the productive contextual use gauges the community-specific and user-desired modifications to their living conditions by offering improvements over existing mechanisms (or substitutes) in ways that were desirable but were previously not recognized or respected (Chattopadhyay et al., 2024). In their pursuit of assessing the context-particular productive use of technological interventions, engineering practitioners can start by inquiring, for instance, about the following.

- How do stakeholders conceptualize challenges and needs in their daily lives? What are the root causes (social, economic, technological, or political) of these challenges? Can the technological intervention address these challenges? If so, in what ways?
- What are the motivations of various stakeholders (including the engineering practitioner them self) as they engage with the technological intervention?
- Are alternative technological solutions or substitutes available in the community? If so, what are the shortcomings of these alternatives in addressing concerns of the various stakeholders? And how can the technological intervention incorporate solutions to these shortcomings?
- If implemented, how would the various stakeholders practically use the technological intervention?

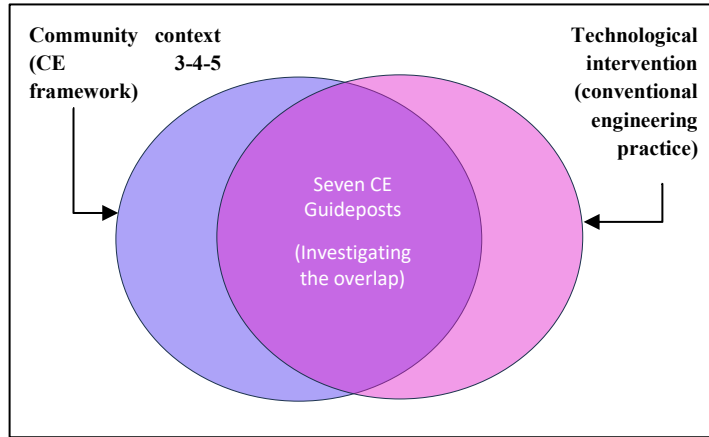


Figure 1 Relationship between community context and technological intervention

- Are there any unintended consequences of the technological intervention that these stakeholders are concerned about?

### *3.2 Interoperability with Existing Systems*

It is well recognized that the dominant, visible and invisible, institutionalized local systems and practices shaped over time often guide the way in which stakeholders interact with each other and their environment (Flint, 2013). These practices influence decision-making processes, sharing of resources, and distribution of power, and are equally crucial to the successful implementation of technological interventions in that community (Chattopadhyay et al., 2024). Consider the recent case study conducted within the Navajo Nation, which compared two technological interventions, the solar home systems program and atmospheric water generation systems program to address electricity and water needs, respectively (Chattopadhyay, 2024). The findings of this study revealed that the solar home systems were more successful, primarily because the Navajo Tribal Utility Authority took advantage of information dissemination and stakeholder engagement systems existing within the community. In contrast, the atmospheric water generation program had limited success, mainly because the donor agency bypassed traditional engagement processes by attempting to interact directly with recipients of the technological intervention without utilizing the established institutionalized mechanisms that had previously proven effective.

Technological intervention must therefore be able to operate within these established systems in order to be embraced and sustained over the long term (Aranda Jan et al., 2016). Due to their nature, developing an understanding of community-specific institutionalized practices is not a straightforward task for a contextual engineer but can be assisted by reflecting upon the following questions:

- How are the community's political, social and economic participation systems/structures organized, and how do the stakeholders engage with these systems? For instance, how are historically marginalized segments represented in the community? How do these systems influence the distribution of power and authority within the community?
- Who holds decision-making power, and how can power dynamics impact the community's ability to adopt the technological intervention? Do some stakeholders have more access to community resources than others?
- What are the preferred methods and tested mechanisms to collect and disseminate information within the community and what is their effectiveness? How can the technological intervention benefit from these mechanisms?

### *3.3 Alignment with Strategic Objectives*

Communities often have shared aspirations to improve their living conditions which drive long-term decision-making and shape a community's collective vision for its future (Mausch et al., 2021). They go beyond documented goals and reflect a shared belief that when individuals' interests are in harmony with those of the group, it benefits everyone (Claridge, 2020). Understanding these goals helps engineering practitioners appreciate what makes the community tick and how they want to be positioned to support regional initiatives and complement broader efforts related to a technology. Contextual engineers can investigate how the community wants to strategically align itself by asking questions including:

- Are there any collective strategic goals related to the technological intervention that have been defined and embraced by the community?
- What is the community's shared future vision and what steps have already been taken to achieve this vision? How do the various stakeholders foresee the technological intervention as assisting in achieving this vision?
- How does the community contribute to or align with regional initiatives or broader efforts related to the technological intervention? Where does the community position itself in achieving these goals?

- Does the community cooperate or compete with neighbouring communities, particularly with respect to the technological intervention?

### *3.4 Compatibility with the Physical Environment*

The success of technological interventions is critically related to their operational compatibility with the existing physical and technological environment and the existing resources and technology support networks within the community (Flint, 2013). Often, technologies are introduced without fully understanding how they will interact with the current infrastructure of the community or the specific needs of key industries. In such cases, in the event of equipment failure, it is extremely difficult to restore normal operation due to the absence of the requisite management processes, limited infrastructure, lack of spares, etc. (Jagtap, 2019). Similarly, the dominant industries within a community influence the likelihood of adoption for technological interventions. Interventions that align with the economic priorities and operational needs of local industries are more likely to be embraced and incorporated into existing workflows, as they establish a sense of continuity with existing structures (Chattopadhyay et al., 2024).

A solid understanding of the compatibility of novel technological intervention with the existing technological structures helps address crucial questions about their deployment such as:

- What is the condition of the community's existing physical environment (climatic and geographical characteristics). How will the technological intervention operate under such conditions?
- What are the dominant industries in the community and what impact does/will the technological intervention have on these industries?
- What resources and services necessary for the sustainable operation and maintenance of the technological intervention currently exist within the community? If none, what additional efforts will be required to meet the specific requirements to operate and maintain the technological intervention? Would these efforts be feasible given the existing community conditions and resources?

### *3.5 Attitude Towards Learning*

The willingness to adopt and maintain alternative knowledge necessary for operating novel technologies is a key factor that engineers must consider when examining technology-context interactions (Wallace, 1995). Communities open to change and committed to continuous learning are more likely to successfully integrate new technologies, ensuring their long-term sustainability and effectiveness. In contrast, communities that resist such adaptation tend to actively preserve their relationship with existing technologies (A.-P. Witmer, 2022). Some questions to consider when gauging a community's propensity to acquiring new knowledge are:

- What is the technological learning capacity of the various stakeholders, and how adaptable are they to new designs? This can be gauged by, for instance, by querying if organizations exhibit their latest technologies at their respective outlets in the community and how does the community respond to these exhibitions.
- What is the availability and condition of training resources and educational facilities within the community? How interested are stakeholders in utilizing these resources to learn about the technological intervention?

### *3.6 Cultural Fit*

Assessing cultural fit involves investigating the traditional and historical value systems that define a community's way of life and how these elements influence the acceptance and effectiveness of technological interventions (Mattson & Wood, 2014; Nakata & Viswanathan, 2012). This is particularly important because the dominant cultures and customs in the community often dictate the trajectory of technological development (Alsaleh, 2024). A classic illustration of how incorporating cultural practices

can improve technical adoption is found in (Nash, 1958), which is focused on the introduction of modern cotton manufacturing to a Maya Indian community in Guatemala. For years, there was an initial resistance to working in the mills due to a mismatch between European work schedules and local customs. The problem was solved after more than 50 years by simply introducing a split workday with a four-hour midday break for household and agricultural duties.

Indeed, technological interventions can function as both disruptor and preserver to the cultural systems, however, the stakeholders' responses to these impacts will be determined by their openness to adapt their value systems. The following list of initial questions can assist the engineering practitioner in framing the cultural understanding of the community:

- What are the shared values of the community and how do these values influence how various stakeholders perceive changes to their physical environment, particularly changes that will accompany the successful implementation of the technological intervention?
- What is the collective worldview of the community and how does it shape their attitudes toward new technological interventions? Is the community open to adapting their value systems to remain technologically inclusive?
- Does the community do anything that is unique to its population and how can their identity influence their adoption or otherwise of the technological intervention?

### *3.7 Confidence in Technological Interventions*

Community confidence is deeply rooted in the collective experiences of the community, especially with respect to similar past interventions and how various stakeholders within the community conducted themselves previously (Kwok et al., 2018; Ranasinghe, 2018). Communities are more likely to trust new technological interventions when they have seen positive results from previous projects, while negative experiences can breed scepticism and resistance (Chattopadhyay et al., 2024). Novice contextual engineers can begin exploring the community confidence in technological interventions by asking questions such as:

- What substitutes/alternatives to the technological intervention or similar technological interventions currently exist in (were previously implemented but are now abandoned by) the community and what are (were) the experiences and grievances with these interventions? How do (did) various stakeholders interact (interacted) with each other in the substitutes/alternatives? What is (was) their level of collaboration, trust, and engagement?
- At what level is (was) the community able to take ownership of similar technological interventions, substitutes, or alternatives?
- How agreements and disagreements between stakeholders related to technological interventions fall within the community? How cognizant should the engineering practitioner be when making decisions related to the technological intervention?

## **4 Conclusion**

This work presents a seven-point conceptualization of high-quality contextual inquiry related to the intersection between technology and community context. It provides an effective tool to engineering practitioners that they can use to collect information that will potentially enable close alignment between technological interventions with the needs and priorities of a community. Indeed, the data collected in exploring these seven dimensions of contextual inquiry is integrated into technical decision-making process to ensure the contextual suitability of a technological intervention. In the future, the authors plan to illustrate the use of the seven guideposts in designing semi-structured interview questions to investigate how electric vehicle technology will influence or be influenced by the local context in Paducah, KY.

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