

Cultivating the Assimilative Perspective in Contextual Engineering – Knowing What You Don’t Know

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Abstract: *Contextual Engineering methodology affords engineering practitioners a more robust process for identifying socioeconomic and cultural conditions within a client community that could affect adoption and sustainability of a technical infrastructure. This methodology seeks to build an assimilative view of the client through direct interactions, which enable practitioners to assess critical local conditions without filtering their understanding through the lens of their own experiences. Some practitioners assert that direct interaction with a client community is unnecessary to achieve an assimilative view, particularly in an era when information is widely available via the internet, and communication with remote partners is possible using a variety of technologies. But assessments of the perceptions of engineering practitioners engaged in two separate projects in Latin America before and after travel to the client communities demonstrate that their understanding of community conditions were altered dramatically once they interacted with residents and experienced site conditions first hand.*

Keywords: Humanitarian engineering, Contextual Engineering, international development, perceptions

1 INTRODUCTION

The practice of Contextual Engineering relies strongly upon an assimilative understanding of client conditions if the engineering practitioner intends to implement an effective technological intervention for an unfamiliar society and builds upon a body of research that exhaustively explores current practices in humanitarian engineering (Witmer, 2018a). This new framework for international engineering draws from existing processes for project design preparation, which can be grouped roughly into two classifications:

- Conditions assessment, as proposed by such researchers as Otte (2013), who used checklists of social variables; Diallo and Thuillier (2005), who used surveys of stakeholder perceptions; and Adomavicius et al. (2007) who modelled conditions using an ecosystem parallel; and
- Decision-making tools, such as a Capacity Factor analysis model proposed by Bouabid and Louis (2105); a project-outcome predictor as proposed by Wicklein (1998); and a dynamic-link logical framework advocated by Khang and Moe (2008).

Unlike these frameworks, though, Contextual Engineering focuses on building within practitioners an assimilative perspective, which requires a self-awareness on the part of practitioners so that they may recognise and compensate for the imposition of their personal beliefs and values upon the design process. But how can an assimilative perspective be developed, and what constitutes sufficient assimilation?

Assimilative perspective is defined in the literature (Witmer, 2018a) as the ability to experience societal context non-judgmentally and with full understanding of alternative

conditions, values, and perspectives. This level of perception is advocated in Contextual Engineering, a rapidly emerging approach to addressing recipient societal needs through technical interventions that relies upon integration of place-based conditions and identities with technology design (Witmer, 2018b). Before the advent of Contextual Engineering, humanitarian engineers have historically solved technical problems using the Engineering Problem Solving (EPS) procedure, a six-step method that explicitly excludes “listening” as a part of the process (Lucena et al., 2010). Some engineering educators actively disparage direct interaction with client societies (Paterson et al., 2016) on the grounds that it doesn’t produce a transformative experience *for the practitioner*, without acknowledging the activities undertaken while interacting are more responsible for influencing outcome than the act of travelling itself. EPS, then, trivialises the value of identifying and understanding unfamiliar contexts that range from divergent belief systems to exotic physical conditions, any of which could have a dramatic impact on functionality, adaptation, and sustainability of an engineered design for the client community.

In reality, EPS unintentionally substantiates the principle of *satisficing*, a concept first proposed by Herbert A. Simon in 1947 and later refined by others to define the act of looking for a course of action that is satisfactory, rather than a course of action that provides the greatest benefit possible (Simon, 1997). Applying this principle to humanitarian engineering, one would conclude that extended exposure to client conditions results in unnecessary effort and expense, particularly when a project can implement technology familiar to the designer by using insights collected from information media and global communications tools. Especially since internet access has become widespread, there’s been a strong movement toward relying on remote data such as video logs and virtual reality imagery, which – combined with print and photographic resources – are heralded as a cost-effective way to develop clear understanding about client conditions (e.g., Pahre, 2017). Thus, for projects undertaken in remote locations, where travel may be expensive and unwieldy, the opportunity to learn about the community using such resources is not only contemplated but encouraged as an efficient way to identify conditions (Stainfield, et al., 2000).

But do such remote methods of inquiry provide a pathway to assimilate the actual physical and societal conditions under which the client society operates? This question perhaps may be best answered using the analogy of myopic individuals who set about cataloguing tree varieties in their neighbourhoods. Not realising their vision is blurred, they identify tree species based on their available perceptive capabilities, using tree size and shape, diciduousity, or colour to distinguish one tree from another. When these same individuals obtain corrective lenses, however, they discover significant additional details they had previously lacked the capability to recognise – bark texture, leaf shape, or symbiotic organism growth, for example. Without the visual capacity to identify these details – resulting in lack of awareness that these details even exist – observers could logically have concluded they had observed all there was to know about a tree. But introduction of a sharper visual acuity creates a new understanding of tree characteristics that couldn’t have been understood previously.

Is an engineering designer functioning myopically when trying to understand a client community from a remote location, using information technology and controlled visuals? This paper explores a preliminary research effort to answer this question, using as case studies two projects in which practitioners from a variety of backgrounds and experiences evaluated client societal conditions – some before traveling and again afterward using a predictive tool developed to assist in Contextual Engineering design. Comparison of evaluations among

practitioner-travellers, as well as analysis of evaluations by native translators and local NGO liaisons who provided initial information about the client community for the projects, offers insight into how societal context may be recognised or ignored based upon personal experiences, objectives, and predispositions. Comparison of pre-travel and post-travel evaluations among one of the groups further suggests that individuals are likely to draw upon their own predispositions initially when predicting place-based conditions, but after assimilative investigation they may be much more convergent in their understanding.

2 METHODOLOGY

The processes and subjects employed in this study are detailed in this section.

2.1 Research Subjects

Initial evaluation of practitioner perceptions was performed using members of a Midwestern Engineers Without Borders (EWB) professional chapter working with a rural village in the Panamanian indigenous region of Ngabe-Bugle Comarca. This evaluation consisted of using a predictive tool developed for Contextual Engineering to assess non-technical conditions that influence adoption and maintenance of an engineered intervention (Witmer, 2018b).

Approximately 15-20 active members of the EWB chapter are practicing professional engineers, and six of those chapter members travelled to Panama in February 2019 to perform first hand assessment of community needs and conditions.

Panama research subjects also included a family of Panamanians who, while not from the project community, are familiar with the area and have assisted the community to seek engineering assistance from the United States. Three family members travelled to the community with the EWB professionals and acted as translators and facilitators. A fourth family member, who completed the EWB application with the community, is a student in the United Kingdom and did not travel with the team but provided them with advance information about local conditions in their preparation for travel. One additional Panamanian engineering student travelled with the team as well, though he had not been involved in providing project information to the group in advance of the trip.

To provide additional analysis of practitioner understanding, the same tool was used by another Midwestern EWB chapter – this time composed primarily of undergraduate engineering students at a large public institution – working with a farming village in the coastal region of Ecuador. Six undergraduate students from the project team, whose members range from freshmen to seniors, travelled to Ecuador in January 2020 for project assessment. Joining this team were two experienced Ecuadoran field managers who work with a partnering Non-Government Organisation (NGO) that assisted the coastal community to apply for EWB support.

2.2 Predictive tool use

To assess consistency of non-technical perception, the Contextual Engineering International Predictive Tool was used with both groups. This tool initially was developed and tested as part of a doctoral dissertation exploring the significance of context in engineering design (Witmer, 2018c). It has since been adopted by EWB-USA as a diagnostic tool that is available for use to all chapters undertaking new projects, and variations of the tool have been created for use domestically and in entrepreneurial applications. The tool consists of 41 questions for the practitioner to answer by observing during travel a variety of local conditions that range

from the way people interact and the processes they employ in decision-making to the accessibility of education and public services to the demographics that are prevalent in the client community. By scoring each of the questions on a Likert scale of 1-5 after completing an on-site assessment trip, practitioners must think deeply about differences between their own experiences and the community's, pushing them to assimilate rather than simply bear witness to conditions they could easily observe without thought.

After returning from travel and completing the tool questionnaire, users upload the results to a web portal and scoring is completed by the tool manager to determine the relative importance of each of five critical non-technical influences to implementation of a technical process. Total values for each influence are summed and normalised to 100% so that relative percentage of each influence is determined. In a utopian society in which all five influences balance equally, we would expect to see 20% scores for each influence. Thus, the larger an influence's absolute deviation from the mean, the greater the critical significance that influence will have upon engineering decision-making (Witmer, 2018b).

The five influences of Contextual Engineering and their significance are presented here:

- Cultural – A shared identity that predominates in a client society, not necessarily shaped by a greater, shared societal identity
- Political –The power dynamics that reside within a client community, regardless of formal governance structures
- Economic –The ability of residents within a client community to meet what they regard as their basic needs, unrelated to monetary wealth
- Educational – A desire of client community residents to acquire new knowledge, distinct from the level of formal schooling or school accessibility
- Mechanical –An aptitude for creating, repairing, adapting, and/or refining devices to make them more functional, unrelated to formal technical training level

The directions given to tool users when they obtain the questionnaire state that travellers should review the questionnaire in advance but resist answering questions until they have spent significant time in the client community. For those questions with which the practitioner struggles, guidance recommends making a best-guess after the trip has ended so that all items have been completed by the time the tool is submitted for scoring.

When the tool was downloaded by the professional chapter before its Panama site visit, one team member (User 1) completed the questionnaire and submitted it immediately, unaware of the guidance to wait until after travel. User 1 relied upon both the information that her own teammates had gathered from previous trips and the first-hand reports from college-educated, local partners who lived near the project and were accustomed to communication in both English and Spanish. These sources were supplemented using web-based research that included both written and visual documentation of the region and its conditions. User 1 was informed that her tabulated results would not be provided to her until after she travelled and completed a new set of questionnaire answers. At that time, both pre-travel and post-travel results would be calculated and she could compare her assumed knowledge of the community with her first hand observations. Teammates, translators, and field representatives also were invited to complete post-travel questionnaires so that conformance of results could be assessed among Panamanians versus non-Panamanians. Additionally, the travel team was

invited to complete the tool post-travel as a collaborative exercise, which would allow the team to reach consensus on each answer by filling in each other's gaps in observation and experience.

To further evaluate the difference between assumed client knowledge and observed conditions, a travel team from the student EWB project was invited in January 2020 to complete the Predictive Tool questionnaire before travel, both individually and as a group, and again after returning from the project site. The project team was advised that they would not be given calculated results from the pre-trip data until after completing their post-travel questionnaires. In this case, the student group relied upon detailed information provided by a multi-national, highly trained NGO staff who work frequently with engineering providers in the United States and undergo rigorous training in information-gathering, relationship-building, and intercultural communications.

Table 1 lists the questionnaire-completion process in terms of recommendations for use, use by Panama User 1, use by Panama travel team, and study-controlled use by the Ecuador student team.

Table 1: Contextual Tool procedures as recommended by the developers, compared with the steps that were followed by participants in Panama and Ecuador travel teams. Note that the process followed by Panama User 1 was accidental, while the process followed by the Ecuador team was prescribed for research purposes.

Contextual tool use for study subjects				
Tool Procedure	Established Procedure	Panama User 1	Panama Travel Team	Ecuador Student Team
Before Travel				
Download Tool from Web	X	X	X	X
Become Familiar with Questions	X	X		X
Individually Complete Questionnaire (no results provided)		X		X
Consult Teammates on Question Meanings	X	X		X
Collaboratively Complete Questionnaire (no results provided)				X
During Travel				
Refine/Discuss Understanding of Questions	X	X	X	X
Perform Field Observations that Address Questions	X	X	X	X
After Travel				
Individually Complete Questionnaire (results provided)	X	X	X	X
Consult Teammates/Collaboratively Complete Questionnaire (results provided)		X	X	X

2.3 Follow-Up Interviews

Practitioners from both teams were interviewed individually as well as jointly after tool use and processing to assess how they scored the tool, from where they had gathered their information before travelling, how their understanding of contextual influences shifted during travel, and whether they considered the results they received to be accurate. Interviews were performed via phone for Panama team members and in person for Ecuador team members, were semi-structured to incorporate unexpected experiences and observations shared by team members as they implemented the tool process, and ranged in length from 30 minutes to 90 minutes.

3 RESULTS

Data collection and analysis using the methodology discussed above is presented in this section.

3.1 Pre-Travel versus Post-Travel Perceptions for User 1

The accidental completion of the predictive tool before travel by professional EWB practitioner User 1 provided a glimpse into how a design-team member may perceive a client community, relying on her own information filters and the veracity of her information sources, before conducting a first-hand on-site investigation. Table 2 shows the calculated relative influence results of User 1’s tool responses before and after travel. Before visiting the community, she perceived that members of the client community struggled to meet their perceived basic needs (Economic Influence) and this governed their ability to adapt and operate an engineered infrastructure. But after visiting and completing a new predictive-tool questionnaire, User 1’s understanding of the community shifted strongly toward recognising the influence of a strong local identity, values, and beliefs (Cultural Influence), which became the predominate infrastructure-acceptance determinant identified by her tool scoring.

Table 2: Individual perception of team member 1 before and after travel for Ngabe-Bugle Comarca, Panama, client community (red cell is greatest influence for a given subject, green cell is least)

Results for Panama 1 User		
Influence	Weighted Score pre-travel	Weighted Score post-travel
Cultural	19.9%	26.1%
Political	19.5%	19.3%
Educational	20.3%	19.7%
Mechanical	17.7%	17.7%
Economic	22.5%	17.3%

3.2 Pre-Travel versus Post-Travel Perceptions for Panama Travel Team

User 1’s post-travel perception aligned closely with the observations of a fellow practitioner who travelled at the same time and completed only a post-travel questionnaire, as is shown in Table 3, as well as with the scores produced from tool use by the majority of translators and field-support local resources and community liaison who worked with the travel team.

Table 3: Comparison of scores for translators, community liaison, local resource and EWB traveling team members (red cell is greatest influence for a given subject, green cell is least)

Results for Panama Travel Team					
Subject	Cultural	Political	Educational	Mechanical	Economic
User 1 (pre)	19.9%	19.5%	20.3%	17.7%	22.5%
User 1 (post)	26.1%	19.3%	19.7%	17.7%	17.3%
Fellow Traveller	26.6%	20.3%	18.6%	12.8%	21.6%
Translator 1	26.1%	20.0%	19.5%	12.8%	21.6%
Translator 2	21.9%	23.3%	17.1%	18.0%	19.7%
Translator 3	25.7%	19.9%	20.2%	17.4%	16.9%
Community Liaison	26.5%	20.9%	18.8%	13.1%	20.8%
Local Resource	20.4%	22.5%	20.0%	18.1%	18.9%
Collaborative ¹	26.2%	21.0%	18.0%	14.0%	20.7%

Key:

TM=team member; Trans=Translator; CL=community liaison; LR=local resource

1. Collaborative group = TM 1, TM 2, Trans 1, Trans 2, CL 1

Interviews with the practitioners after travel indicated that they realised when reviewing the tool results that they did not actually possess a strong understanding of the society with which they were working before they travelled, though they had previously believed they were cognisant of all local conditions. Several interviewees indicated that while they knew more about their client than they would have without employing the tool, they also developed a strong awareness of the limitations of their knowledge, which they described as beneficial in that it challenged them to question their assumptions and predispositions more rigorously. The image they had constructed pre-travel was built mostly from information they had received through correspondence and conversations with the community liaison, whom they deemed to be honest and forthright in communications but unable to fully convey a clear picture of conditions about a community that was so unlike the home experience for the EWB professional team. As a supplement to the information provided by the liaison, the team relied upon data gleaned from web searches and available publications, again deemed to be accurate and honest in their depiction of the Panamanian society but incomplete in their descriptions.

3.3 Pre-Travel versus Post-Travel Perceptions for an EWB Ecuador Team

Because the unexpected opportunity to compare pre-travel and post-travel perceptions yielded startling differences in community understanding for User 1, an additional trial was performed in which an entire team’s understanding of their own client community was tested before travel and compared to post-travel perceptions, using the Predictive Tool. In this case,

six members of a university EWB team travelled to coastal Ecuador in January 2020 after spending nearly a year researching their client’s conditions and identity. Team members filled out the Predictive Tool individually then completed it collaboratively, negotiating scores for each of the 41 questions to reach a consensus. The team then spent eight days on site, following the Contextual Engineering tool recommendation of investigating physical, societal, political, and economic conditions, before completing the questionnaire once more both individually and collectively. The results of pre- and post-travel relative influences identified by the team are shown in Table 4.

Table 4: Individual and team perceptions before and after travel for El Guarango, Ecuador Project Team indicate that site observation produced strong conformity of understanding (red cell is greatest influence for a given subject, green cell is least)

Pre-travel					
	Cultural	Political	Educational	Mechanical	Economic
Individual	21.90%	19.10%	20.00%	18.20%	20.80%
	22.40%	24.20%	13.70%	18.60%	21.10%
	18.00%	20.70%	22.90%	18.60%	19.80%
	22.40%	18.70%	19.00%	23.00%	16.90%
	23.20%	27.10%	12.60%	12.20%	24.80%
	23.10%	22.20%	17.60%	15.40%	21.80%
	Group	21.70%	20.20%	18.70%	18.10%
	Cultural	Political	Educational	Mechanical	Economic
Individual	18.50%	18.90%	20.50%	19.50%	22.60%
	17.20%	19.80%	21.40%	19.20%	22.50%
	19.30%	20.20%	20.00%	19.10%	21.40%
	18.80%	21.60%	17.40%	19.00%	23.10%
	14.30%	20.70%	21.40%	19.50%	24.10%
	14.10%	21.50%	20.50%	18.70%	25.10%
Group	16.50%	19.00%	20.70%	19.10%	24.70%

One can see from the colour scale of relative influences for each individual practitioner that perspectives before travel varied widely among the group in identifying the most critical influence, with two members viewing cultural influence as most significant, two members viewing political influence as dominant, and one member each viewing educational and mechanical influences as most critical. Not one of the practitioners, however, perceived the economic influence as strong within the client community, even when the team completed the tool collectively after negotiating their pre-travel scoring. After travel, however, all six practitioners viewed the client community’s contextual influences similarly, at least in terms of most and least significant relative influences. The tool scores that resulted from those individual perceptions also aligned strongly with the influence scores for the group-negotiated tool outcome, which identified as the most dominant influence the community’s inability to meet what it considers its basic needs; the group outcome also found that the least significant influence was a commonly shared and valued sense of identity that aligns with a set of values and/or beliefs – the very influence that they jointly identified as most critical before travel.

3.4 Perceptions based on project role

After the professional team's travel to Panama was complete and individual questionnaires were returned and processed, the Predictive Tool was distributed to the travel team's translators and local resources, including the community liaison, to determine whether perceptions differ depending upon the role the assessor plays. Additionally, combinations of team-role participants were invited to complete the tool collaboratively. The purpose of this exercise was to determine whether those experts already familiar with Panamanian society had a different understanding of its context than the U.S. practitioners had after the travel experience was complete, as well as to determine whether collaborative tool completion yielded different results than the average of individual observations. Table 3 presents the results of individual post-travel results for each of the three translators, the liaison, and the local resource, as well as a collaboration of the two practitioners, two translators and community liaison. Results demonstrate a strong alignment of perception that cultural identity is a governing influence for the Panamanian community, regardless of tool-user role or of collaboration. It is interesting to note, however, that the client liaison and one translator were more attuned to political influence than the remainder of the group, not to the degree, though, that they influenced the final collaborative outcome.

4 DISCUSSION

The accidental discovery that a practitioner's perceptions of a client community may change dramatically after immersion into the client's daily life provided a basis for further investigating how strongly we rely on incomplete information about our clients' needs in designing infrastructure when we do not travel, explore, inquire, and observe. Of particular interest while pursuing this research path was examining what practitioners rely upon for client information when they are unable to draw upon their own interactions with the place and people. As the professional practitioner and student team both explained, much of the information they acquired about their clients came through local resources that may have unintentionally filtered their understandings of the village. Were those pre-travel perceptions misguided because of deliberate manipulation of information to achieve maximum support for the project, as may be assumed if one subscribes to Krause's analysis in her book, "The Good Project" (2014)? Krause's conclusion is that NGO drivers focus on organisational self-preservation rather than client need. An equally likely alternative interpretation is proposed in Witmer (2018c) that concludes perception of community context improves with increasing familiarity until it reaches a point in which the assessor begins to identify as a community member rather than an observer. Should this stage of perception, labelled "integration," occur with local contacts, they may be so familiar with a client society that they identify with a portion of it, thus shifting their own perceptions toward those of the segment itself and losing sight of the heterogeneous whole. Such an integrated perception may unintentionally result for field representatives or client contacts who have become so familiar with the community or the region that they fail to perceive the nuances that exist specific to place and time.

Regardless of how pre-travel information is gathered, the results of this study provide strong initial indications that true contextual understanding doesn't occur until the practitioner interacts with the client community directly and experiences the people, place, beliefs, and practices that reside specifically in that place at that time.

5 CONCLUSIONS

Engineering practitioners who have been educated using the EPS process are predisposed to believing they have a sufficient understanding of local context associated with an international engineering project even if they have had no direct interaction with the community or experience in evaluating values, experiences, identities, and dynamics associated with society. In reality, it is very difficult to establish an assimilative view to inform design unless practitioners experience the client location first hand and spend time gathering information and experience in examining its societal as well as physical conditions.

Resources upon which practitioners rely to provide a remote understanding of local conditions, ranging from online information services to conversations with local liaisons, may not intentionally obscure their understanding of local conditions but may not provide a complete and non-biased understanding of the client.

6 ACKNOWLEDGEMENTS

The author wishes to thank professional EWB project practitioners Elena Stachew and Ashley Robbins, as well as undergraduate EWB project practitioners, translators, and non-government field support, for their participation in this research effort. This research process was conducted with approval from the Institutional Review Board of the University of Illinois at Urbana-Champaign, Protocols #16860 and #18431.

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