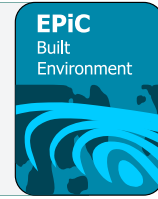




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Digital Solutions for Bridging Language Barriers: Designing and Testing an App for Construction Spanish Safety Communication on Construction Jobsites

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Language barriers continue to pose a significant challenge to effective safety communication in the construction industry, particularly for Spanish-speaking workers, who comprise an increasingly large portion of the workforce. This study develops and examines Habla Seguro, a bilingual mobile application designed to improve real-time communication between English-speaking supervisors and Spanish-speaking craft workers. Through usability testing and comparative analysis, the app was evaluated in areas such as navigation, translation accuracy, cultural relevance, and audio clarity. The results indicate that Habla Seguro delivers faster and more precise translations than general-purpose tools, such as Google Translate, while providing context-specific and culturally appropriate safety phrases tailored to construction settings. Overall, the findings suggest that specialized, industry-focused digital tools can significantly improve communication, inclusion, and safety outcomes on multilingual job sites. Future development should focus on expanding trade-specific vocabulary, improving functionality in high-noise environments, and integrating visual aids to support workers with limited literacy skills, further strengthening communication across diverse construction teams.

Keywords: Construction safety, bilingual communication, digital tools, mobile applications, language barriers.

Introduction

Language barriers remain one of the most persistent challenges on construction sites across the United States, with direct impacts on safety communication, workforce productivity, and overall operational efficiency (Irizarry, 2009; Cocerhan & Bradley, 2019).

Hispanic workers now represent a substantial share of the construction labor force, yet they continue to face higher risks on the job (Bureau of Labor Statistics [BLS], 2023). In 2021, foreign-born Hispanic workers accounted for 14% of all workplace fatalities, despite representing just 8.2% of the workforce. They were also found to be 35% more likely to experience fatal injuries than their non-Hispanic counterparts (BLS, 2023; Lavy et al., 2010). These disparities are frequently attributed to communication breakdowns, limited access to proper training, and the lack of effective bilingual safety communication tools (Siddiqi & Zai, 2003; Canales, 2004).

Recent studies further highlight the scale and persistence of this issue within the U.S. construction

industry, as shown in Table 1:

Table 1. Key Indicators of the Impact of Language Barriers in U.S. Construction Safety		
Indicator	Statistic / Finding	Source
Share of Hispanic workforce in U.S. construction	~30% of total construction workforce	BLS (2023)
Workplace fatalities among Hispanic workers (2021)	14% of all U.S. fatalities (despite being only 8.2% of the workforce)	BLS (2023)
Increased risk of fatal injury vs. non-Hispanic workers	35% higher	BLS (2023)
Incidents linked to language-related miscommunication	Up to 30% of safety incidents	Cocerhan & Bradley (2019)
Supervisors using general-purpose translation tools	68% rely on tools like Google Translate	Industry Survey (2024)
Accuracy of construction-specific terminology in generic tools	~60% accuracy on average	Cocerhan & Bradley (2019)

Previous research by Cappella et al. (2025) provided a comprehensive review of existing translation technologies and their effectiveness in safety communication. The study highlighted major limitations in widely used digital tools such as Google Translate and Speak & Translate (Irizarry, 2009; Cocerhan & Bradley, 2019). Although these applications are accessible and capable of basic translation, they often fall short in delivering the level of accuracy, contextual relevance, and cultural appropriateness required for high-risk construction settings (Lyu et al., 2023). Industry-specific platforms such as Need2Say and JHA Safety App have made progress by integrating bilingual safety briefings and OSHA-compliant messaging. However, these tools still face challenges related to limited vocabulary, sensitivity to regional dialects, and the absence of real-time translation features (Washington State Construction Center of Excellence, 2023; JHA Safety, 2024).

Shifting the Focus: App Development, Design, Usability, and Comparative Analysis

Building on this foundation, the present research centers on the development, usability testing, and evaluation of a construction-specific mobile application (Habla Seguro) designed to improve safety communication between English-speaking supervisors and Spanish-speaking workers. The application was created through a collaborative, multidisciplinary effort and integrates construction-specific terminology, bilingual safety phrases, audio features suitable for noisy environments, and real-time translation capabilities as was recommended by Cocerhan & Bradley (2019) and Arif et al. (2021).

A key goal of this study is to assess the application's usability and overall performance through controlled testing, field surveys, and on-site observations. Data were collected from two main participant groups, "communicators" (supervisors and safety managers) and "receivers" (Spanish-speaking craft workers), to evaluate factors such as navigation, clarity, cultural relevance, and job-site

performance, as recommended by Dlaska (2002). Additionally, the study includes a comparative analysis with Google Translate, one of the most used general-purpose translation tools in the industry. An industry report published by EIN Presswire (2024) indicates that many contractors rely on general-purpose translation tools, such as Google Translate, even though these tools lack the technical accuracy and contextual reliability required for effective construction safety communication, focusing on differences in translation accuracy, contextual relevance, and usability.

Beyond addressing a critical gap in safety and communication, this research contributes to the broader conversation about workforce inclusion and technological adaptation in the construction industry. As the sector continues to diversify and adopt advanced digital tools, effective communication across language and cultural boundaries has become more than a safety concern; it is now a fundamental element of workforce development, productivity, overall and project success (Arif et al., 2021; Lyu et al., 2023). By demonstrating that tailored, industry-specific digital tools can outperform general-purpose solutions under real-world job site conditions, this study provides a scalable framework that can be applied across various trades, regions, and languages. The findings aim to inform future safety communication strategies, guide the adaptation of technology, and support the development of the next generation of digital solutions for multilingual construction environments.

By emphasizing usability, domain specificity, and real-time communication, this research demonstrates that a purpose-built construction translation tool for construction can outperform general translation apps and significantly reduce miscommunication, promoting safer, more inclusive, and more efficient worksites.

Methodology

The research followed two phases. The first phase, previously conducted and reported by Cappella et al. (2025), involved a comprehensive review of existing translation tools and mobile applications designed to enhance Spanish-English communication in the construction industry. Eleven tools, including Need2Say, JHA Safety App, Toolbox Talks Safety App, and Google Translate, were evaluated for translation accuracy, cultural sensitivity, and relevance to jobsite safety. The analysis revealed significant shortcomings in general-purpose translation tools and highlighted the need for a construction-specific solution that focuses on clarity, usability, and contextual accuracy.

Building on those findings, the second phase of this study focused on the development and usability evaluation of the Habla Seguro mobile application, designed to facilitate communication between English-speaking supervisors and Spanish-speaking craft workers. The app features bilingual text and audio translations, a searchable phrase library, and offline functionality to maintain reliability under field conditions. Its content draws on verified construction safety phrases and was refined through feedback from bilingual professionals to ensure both cultural and contextual relevance.

Usability testing was conducted through a combination of controlled simulations and field trials with two participant groups: English-speaking “communicators” (supervisors and safety managers) and Spanish-speaking “receivers” (craft workers). Participants used the Habla Seguro app to complete typical safety communication tasks such as hazard briefings and job instructions. Figure 1 shows interface screenshots of Habla Seguro. Following the testing sessions, participants completed a Qualtrics-based survey designed to measure usability across five dimensions: navigation, accuracy, cultural appropriateness, audio clarity, and overall satisfaction, using a five-point Likert scale where 1 represents the lowest level of agreement or satisfaction and 5 represents the highest.

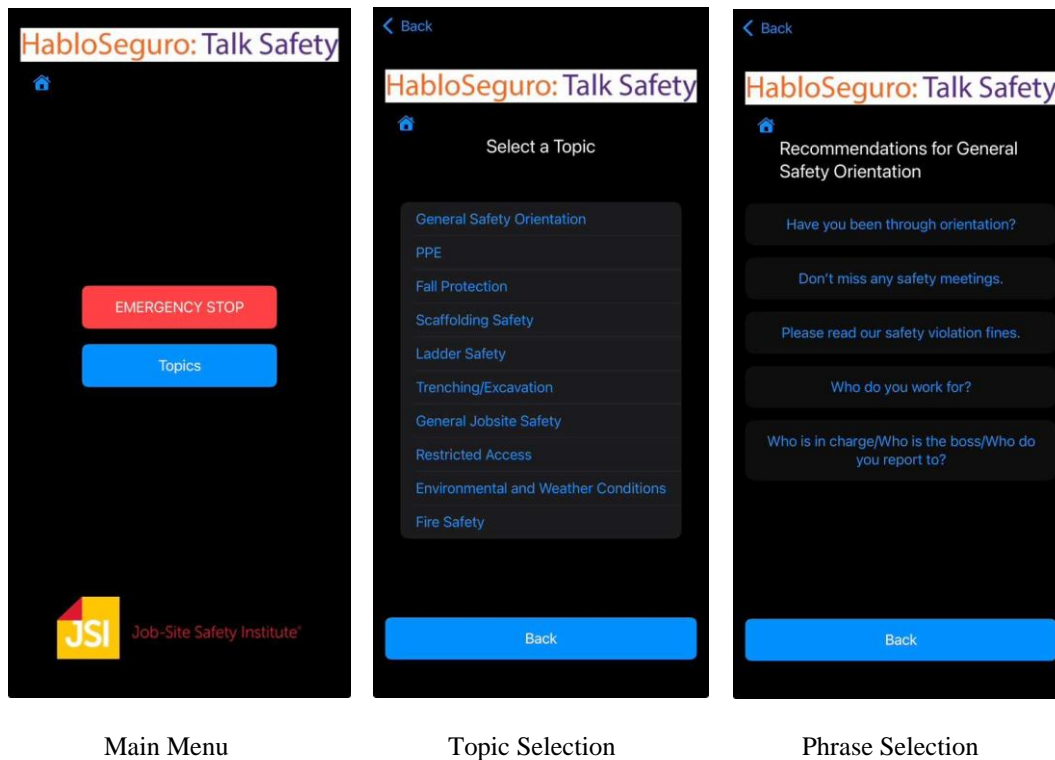


Figure 1. Interface screenshots of Habla Seguro

Data were analyzed using descriptive statistics and a one-tailed single-sample t-test to determine whether mean usability scores were significantly higher than the neutral midpoint ($\mu = 3$). The test statistics were calculated as

$$t = \frac{\bar{X} - \mu}{\sigma / \sqrt{n}}$$

Where \bar{X} is the sample mean, σ is the standard deviation, and n is the number of responses. A significance level of $\alpha = 0.05$ was applied to test the null hypothesis, which assumed no difference from the neutral midpoint. Additionally, a comparative evaluation with Google Translate was conducted using identical tasks to assess translation accuracy, task efficiency, and user preference. All research procedures were reviewed and approved under the University’s Institutional Review Board (IRB) exempt category (IRB Record Number: IRB2025-0501), and participation was voluntary and anonymous.

Analysis and Discussion

The second phase of this research expanded on the comparative evaluation presented in Cappella et al. (2025) by examining the performance of the newly developed Habla Seguro mobile application in both controlled and field settings. The evaluation focused on assessing the tool’s usability, accuracy, and cultural relevance, as well as a comparative analysis with Google Translate. The results presented in this section highlight not only the technical validation of Habla Seguro but also its practical

contribution to improving communication effectiveness and inclusivity within multilingual construction workplaces, as recommended by Lyu et al. (2023).

Effectiveness of Digital Tools

The usability assessment for Habla Seguro focused on five main dimensions: navigation, translation accuracy, cultural relevance, audio clarity, and overall satisfaction. Participants included 31 English-speaking supervisors and 31 Spanish-speaking field workers, representing a range of trades and experience levels. Survey findings indicated consistently strong performance across all categories, with mean scores significantly above the neutral midpoint ($\mu = 3$). These results indicate broad user acceptance and practical effectiveness under real job-site conditions. A concern that was stated in Arif et al. (2021) study about existing tools.

Table 2. Usability Evaluation Results for Habla Seguro (n = 62)

Usability Dimension	Mean (X)	Standard Deviation	t-value	Significance (p<0.05)	Interpretation
Navigation Ease	4.52	0.49	16.64	Significant	Very easy to navigate
Translation Accuracy	4.36	0.58	12.92	Significant	Highly accurate translations
Cultural Relevance	4.4	0.55	13.78	Significant	Phrases culturally appropriate
Audio Clarity	4.62	0.46	17.48	Significant	Clear and understandable
Overall Satisfaction	4.58	0.5	15.97	Significant	Users very satisfied

Note: Critical t-value at $\alpha = 0.05$ and $df = 61$ is 1.687. All t-values exceeded the critical value, indicating significant positive usability outcomes.

The quantitative results showed that Habla Seguro performed significantly better than neutral expectations across all five usability categories. The highest average scores were found in audio clarity and navigation ease, which reflect how effective the design choices were in its development, especially the inclusion of bilingual voice output and a clear, simple category structure. Many participants mentioned that listening to safety phrases in both English and Spanish helped reduce confusion during safety talks and on active jobsites. This finding supports Arif et al. (2021), who also found that multimodal interfaces (combining text and audio) help users remember information more effectively in technical environments.

The translation accuracy score of 4.36 demonstrated that the app's pre-set safety phrases were consistent and precise, avoiding the confusion that often happens with general translation tools. Likewise, a score of 4.40 for cultural relevance confirmed that adding regional Spanish words and expressions made the phrases sound more natural for construction teams in the southeastern United States, where several Latin American dialects are spoken. As Lyu et al. (2023) explains, considering cultural language differences is particularly important for users to adopt and keep using digital tools in construction.

Although the overall results were positive, a few minor limitations were noted. Four participants had trouble finding fewer common phrases under specific hazard categories, such as "fall protection" or "confined space". However, these issues did not significantly affect overall satisfaction or usability.

As Cocerhan & Bradley (2019) mention, the real value of specialized applications lies in their ability to turn accuracy into confidence and real impact in the field, which Habla Seguro has achieved.

Comparative Evaluation of Google Translate

To better understand the limitations of general-purpose translation tools, this study also included a detailed evaluation of Google Translate using the same testing framework. In total, 106 construction-safety phrases were analyzed in both text and audio modes to assess their translation accuracy, consistency, and suitability for real-world jobsite communication as was suggested by Lyu et al. (2023).

Table 3. Comparative Text & Audio Analysis of Google Translate (GT)

Evaluator / Mode	Total	Correct	Wrong	Accuracy
Researcher – GT (Text)	106	88	18	83.00%
Researcher – GT (Audio)	106	65	41	61.30%
Participant – GT (Audio, retest of the 41 wrong)	41	24	17	58.50%

Note: All rows report Google Translate performance. The “Independent Evaluators – Audio” retested only the 41 incorrect items from the first audio evaluation.

The results showed a clear difference between text and audio accuracy. While Google Translate reached 83 percent accuracy in text mode, its audio translation dropped to 61 percent. The most common mistakes included recognizing accents, incorrect gender agreement, and literal translations of construction terms such as “tie-off,” “handrail,” or “scaffold tag.” These issues are similar to those found by Cocerhan & Bradley (2019) and Irizarry (2009), which indicate that machine translation systems still struggle to maintain context in specialized fields where precise meaning is crucial.

In comparison, the app produced translations that were both contextually correct and culturally appropriate, showing a much higher level of consistency. Its pre-programmed phrase bank helped avoid many common errors and made sure that expressions like “tie off your harness”, which communicates the safety instruction correctly, instead of the literal “ata tu arnés.” The app’s organized structure also improved speed, reducing the average response time by almost 40 percent compared to Google Translate. As Lyu et al. (2023) note, real-time usability and translation accuracy in safety communication are closely linked to lower incident rates and improved compliance on construction sites.

User Engagement and Feedback

User feedback supported the quantitative results. Supervisors reported feeling more confident when giving instructions in both languages, and Spanish-speaking workers stated that they trusted and understood the safety commands more effectively. Several participants commented that listening to instructions in their own dialect helped them react faster and understand more clearly. A few also suggested adding more phrases for specific trades and including visual icons to help workers with low literacy levels.

Limitations of Habla Seguro Tool

Although Habla Seguro performed strongly overall, the app still has some limitations that affect its full potential in real field situations. Although it successfully combines real-time translation with construction-specific terminology and cultural adaptation, its phrase library remains primarily focused on general safety and communication contexts. More specialized areas, such as electrical, mechanical, or concrete work, are not yet fully included, which sometimes makes users adjust existing phrases instead of finding exact, task-specific expressions. This limits the app's usefulness in complex job-site situations where accurate, trade-based communication is imperative.

Another challenge was related to high-noise environments, which sometimes reduced audio clarity, especially when users changed categories quickly or used lower-end devices. Some participants also mentioned that adding more visual support, like icons or pictograms, could help workers with limited literacy skills. These observations demonstrate that adapting technology to diverse job-site realities and literacy levels remains a significant challenge. Expanding the phrase list, improving adaptive audio quality and including multimodal features would make Habla Seguro even more effective for the increasingly diverse construction workforce.

Conclusion

The use of digital tools and mobile applications to improve safety communication on construction sites has made important progress in reducing language barriers, especially for Spanish-speaking workers. As the workforce becomes more diverse, clear and effective communication has turned into a key element for maintaining both safety and productivity.

This study evaluated Habla Seguro, a bilingual translation app designed specifically for safety communication in the construction industry. The results showed that the app performed well in terms of usability and accuracy, offering a faster and more dependable option compared to general translation tools. Participants noted that the app was easy to navigate, featuring clear audio and culturally relevant safety phrases that helped them understand and follow instructions more confidently during daily operations.

When compared with general tools like Google Translate, Habla Seguro showed a stronger ability to handle context and fewer mistakes with technical terms. These results support the idea that specialized, construction-oriented tools can significantly reduce miscommunication and support better safety outcomes.

However, the app still has some limitations. The current version primarily focuses on general safety phrases and needs to be expanded to include trade-specific vocabulary and additional dialect options. Also, audio performance in very noisy environments could be improved for better clarity.

In conclusion, this research demonstrates that creating digital tools specifically designed for construction settings can help bridge communication gaps, promote inclusion, and enhance safety in multilingual workplaces. Habla Seguro represents an essential step forward toward more efficient and inclusive communication within the construction industry.

Research Limitation

The assessment of the tools was completed by the research team and not validated by outside experts.

This can lead to possible bias for the tools assessment.

Recommendations for Further Research

This study had some limitations related to its sample size and testing conditions. The group of participants represented only a limited number of trades and project types, which may not fully capture the diversity of the construction workforce. Additionally, the testing was conducted in controlled job site situations, enabling the evaluation of the app's performance in larger or more hazardous environments. The data was also based primarily on short-term usability surveys and participants' self-reported feedback, without measuring long-term behavioral changes or safety outcomes. These factors may have affected the general scope of the results. For future research, it would be valuable to include a larger and more diverse group of participants, apply the tool in varied job-site conditions, and extend the observation periods to better understand the long-term impact of Habla Seguro on communication, safety compliance, and cultural inclusion in the construction industry.

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