

Using 3D Visualization to Train Hispanic Construction Workers

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Construction jobsites are one of the most dangerous workplaces in the United States. Due to the large number of Hispanic construction workers, cultural and language barriers between English-speaking construction management personnel and their Spanish-speaking workforce is a growing concern, particularly with regard to jobsite safety. This paper explores the use of 3D visualization to train Hispanic construction workers. It applies guidelines developed for educational materials targeted to Hispanic workers. The findings suggest that 3D visualization can be an effective tool to train a diverse population if guidelines are followed to ensure that the approach in language and culture are appropriate.

Key Words: Safety Training, Hispanic construction workers, bilingual, e-learning, BIM

Introduction

Many construction accidents could be avoided by using improved engineering and administrative controls, and providing improved safety training. 3D visualization and analyses are situated to play a critical role in enhancing safety training for both Spanish speaking and non-Spanish speaking laborers. At Colorado State University, the authors are partnering with industry to develop an interactive learning module to teach construction safety practices to Spanish-speaking laborers. While the narrated module can also be played in English, it has been developed to meet Brunette's guidelines for educational materials targeted to Spanish speaking workers (Brunette, 2005). The result is an interactive module using a professionally developed Building Information Model (BIM) to visually represent with a high degree of accuracy the geometric relationships and construction sequencing of real-world brick-veneer wall assembly while, at the same time, providing specific reference to the safety precautions necessary to complete such work. The safety training module leverages the integration of 3D visualization with an accompanying, Spanish narrative- two means of communication highly accessible to native Spanish speakers. Future work will further refine the teaching module and test it on Spanish-speaking construction workers in both the United States and Mexico.

Background and Literature Review

The number of Hispanics in the U.S. has increased steadily in the last few decades. In 2000, Hispanic population accounted for 12.4% of all U.S. residents, or 35.3 million of the 281.4 million U.S. residents (U.S. Census Bureau, 2005). In 2004, the construction industry employed 21% Hispanic workers, significantly more than the average of 13% for all industries (Simpson, 2006). Due to the large number of Hispanic construction workers, cultural and language barriers between English-speaking construction management personnel and their Spanish-speaking workforce is a growing concern, particularly with regard to jobsite safety. Hispanic construction workers are twice as likely to get injured on the jobsite in the United States than non-Hispanic workers (AFLCIO, 2005).

In an effort to reduce the health and safety disparities between Hispanic construction workers and Anglo construction workers, National Institute of Occupational Safety and Health (NIOSH) and Occupational Health and Safety Administration (OSHA) organized the first National Action Summit for Latino Worker Health and Safety in April 2010 (OSHA, 2010). In this summit David Michaels, Assistant Secretary of Labor for Occupational Safety and Health, clarified OSHA's position regarding training construction workers. The following statement was issued in a memorandum:

“...Many OSHA standards require that employees receive training so that work will be performed in a safe and healthful manner... It is the Agency's position that, regardless of the precise regulatory language, the terms "train" and "instruct," as well as other synonyms, mean to present information in a manner that employees receiving it are capable of understanding ... In practical terms, this means that an employer must instruct its employees using both a language and vocabulary that the employees can understand....”

Understanding the Hispanic culture is essential to having a successful safety training program. Construction workers often have limited English proficiency making them less likely to request personnel protective equipment and report unsafe situations. Compounding the problem is the limited formal education that most Hispanic construction workers have received. This often makes the traditional approach of presenting safety material in technical terms and in English ineffective.

As construction sites become more diverse, effective training of minority construction workers is a growing concern. The potential for visualization and simulation to aid in safety training is significant. BIM increasingly is being used by Architecture, Engineering and Construction (AEC) professionals to produce, analyze and manage design and construction information. However, the models used to generate this information are not being shared directly with on-site workers (Mourgues, 2008), and, in particular, the findings are not being communicated effectively to non-English speaking laborers. This shortcoming represents significant opportunity. 3D visualization and interactive, non-verbal simulation enhance learning and can facilitate training. Furthermore, leading general contractors are now using BIM visualization and analysis techniques to greatly enhance safety programs both during pre-planning and construction phases (Lopez del Puerto and Clevenger, 2010). This paper provides insights into ways that 3D visualization can be used to educate construction workers about project specific construction processes and potential construction hazards.

3D Visualization Training Program

3D visualization modules increase training effectiveness and facilitate better communication among diverse team members since visual representation in general, and interactive, 3D viewing environments in particular, reduce the amount of verbal description required to produce common understanding. In order to investigate the applicability of 3D visualization to train Hispanic construction workers, the authors are developing a training module focusing on the relationship of construction sequencing to essential engineering and administrative safety controls. The training module is based on a virtual wall assembly model created by Mortenson Construction. The professionally developed wall assembly model was originally built using Google® Sketch-up® for purposes of a constructability analysis. Once created, however, the authors recognized additional value in using the visualizations as the basis for safety training material. For this purpose, the Google Sketch-up model is viewed as a 3D animation using a sequence of scenes to illustrate discrete construction stages. Associated with each of these stages are required or recommended safety practices and procedures. These safety controls have been constructed in the Google Sketch-up model and similarly illustrated through a sequence of scenes. The animation is then captured and presented as an interactive training module using Adobe® Captivate® 5 software. Notably Adobe Captivate 5 software is viewable using various web browsers and while it simulates interaction with the native software, in this case Google Sketch-up, it is platform independent and is viewable without access to the native software. Finally, the interactive training module was both visually and audibly annotated with narrative to enhance the learning environment. Using Adobe Captivate, it is possible to add written annotation as well as digitally recorded voice-over or to use text-to-voice software to automate narration to software viewing. While the automated text-to-voice feature increases ease of development through text editing and seamless translation into multiple languages, the authors chose to rely on digitally recorded voice-over by a native Spanish speaker to increase the comprehensibility of the instruction.

In creating the visual and accompanying audio content of the safety training module, the authors followed the guidelines developed for educational materials targeted to Hispanic workers (Brunette, 2005). We outline our execution of these guidelines here:

Table 1: Implementation of Brunnette's guidelines to develop educational material for Hispanic workers as applied to an interactive teaching modeling on construction safety using BIM.

Guideline	Implementation in educational material
Use a native-speaking Spanish translator who has in-depth knowledge of the topic.	Carla Lopez del Puerto, is an Assistant Professor of Construction Management at Colorado State University where her main research area is construction safety management. She is an Occupational Safety and Health Administration (OSHA) outreach trainer and has trained over 500 students and professionals about construction safety. She is a native Spanish speaker and oversees both the technical and linguistic accuracy of the training narration.
Have Hispanic trainers who are native speakers and provide Spanish-language training.	The animation is narrated in Spanish and by a native Spanish speaker with a limited amount of text regarding OSHA regulations, written in a manner that Hispanic construction workers with a low education level can understand.
Use generic, "standard" Spanish."	OSHA's English-to-Spanish and Spanish-to-English dictionaries were used in script development to ensure that the material developed in this project uses generic Spanish terms approved by OSHA.
Include basic education on OSHA laws and workers' rights to safe and healthy conditions of workers in the training program.	As shown in Figure 1, the 3D visualization model included information about OSHA regulations and workers' rights.
Use of language that is familiar to the workers.	Hispanic construction workers in the United States often use construction terms that are neither in Spanish nor in English but in "Spanglish". For example, the word for forms that is used in Mexico is "cimbra". However, many Hispanic construction workers in the US use the Spanglish word "forma". When we encountered a word that is commonly referred to in Spanglish, we provided both the Spanish and the Spanglish translation where possible and appropriate in both the written annotations and the verbal narration. We keep these annotations and narrations appropriate for a limited education level.
Keep materials at a limited literacy level.	One of the main advantages of using 3D visualization is the use of multiple modalities to train workers with a limited literacy. The training module includes both written and spoken directions. Workers who have limited literacy can complete the training without needing to read the directions. Visual learners who are proficient in literacy benefit by reading the directions in addition to hearing them.
Use plenty of clear and realistic illustrations, graphics and photographs.	Since 85% of people learn by sight, visualization is critical to enhance learning in physical sciences like engineering or construction (Sorby & Baartmans, 1996). 3D visualization capabilities of today's software packages are outstanding and facility accurate and detailed representation in a process referred to as virtual design and construction (VDC). Industry and academia alike recognize that 3D models provide a robust environment for exploration and visualization. Here the authors use the professionally developed Google Sketch-up model illustrating a construction sequence as the fundamental content of the safety training module (Figure 2).
Deliver educational and training program in a learner-centered environment.	The Adobe Captive platform supports interactive e-learning environment capable of providing demonstrations, interactive simulations, branching scenarios, and quizzes outside the original, native software platform.

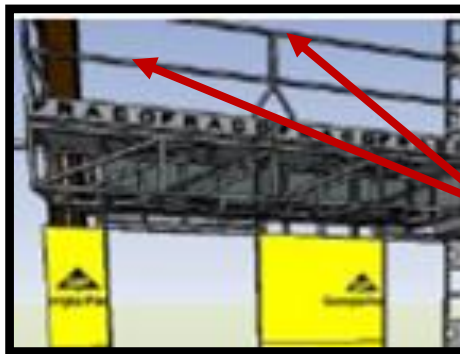
	<p>While not all of these features are currently incorporated in the safety training module, the module is learner centered. Future research will work to further customize these learning environments and include learning assessment features in multiple languages.</p>
<p>Conduct pilot tests with a subset of Hispanic workers.</p>	<p>In future research, we plan to conduct a pilot test with 30 Hispanic workers. We will give participants a short- assessment about their level of understanding about the construction process and safety awareness at the end of the module. We will empower participants to have an active participation in the project by making suggestions and recommendations on ways to make this training program successful.</p>
<p>Establish a continuous evaluation process</p>	<p>The training program will be reviewed by industry experts to ensure that the content is accurate. The training program will also be reviewed by volunteer Hispanic construction workers to ensure that the material meets their expectations and that the language and cultural approach are adequate. An assessment will be given to participants at the end of the module to measure their level of understanding about the construction process and safety awareness. A survey will also be given to participants asking them for feedback and suggestions to improve the module. The results will be used to fine-tune the final curriculum and develop project specific training programs for future projects.</p>

Figures 1 and 2 provide additional information to demonstrate the implementation of the guidelines outlined in Table 1.

Audio Narration:

“Usted tiene el derecho de pedir a la OSHA que realice una inspección si usted piensa que en su trabajo existen condiciones peligrosas o poco saludables”

“You have the right to request an OSHA inspection if you believe that there are unsafe and unhealthful conditions in your workplace” (OSHA 2,n.d.)



Audio with visual reference.

“Al trabajar en andamios de 6 pies o más de altura, los barandales/ barandillas deberán ser instalados”

“When working on scaffolds 6’ above lower level, guardrails must be installed” (OSHA , n.d.)

Figure 1: Example audio and visual representation of basic education on OSHA laws and workers’ rights provided in the training module for Hispanic workers.

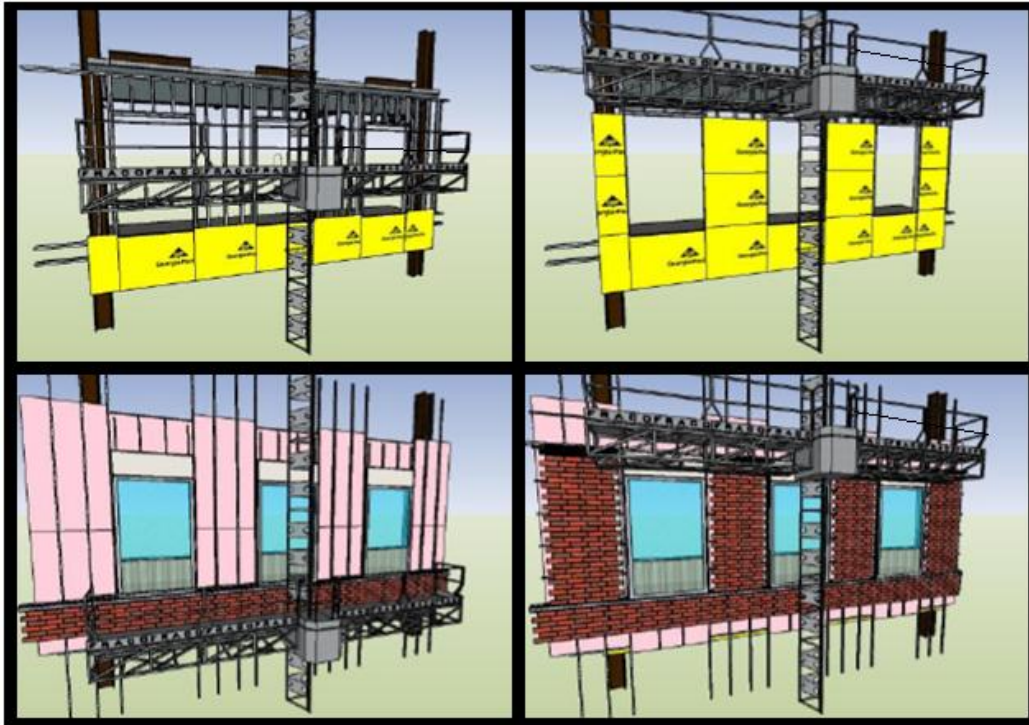


Figure 2: Animated sequence of 3D visualizations used to illustrate construction sequencing and associated safety controls.

Discussion

Although research exists highlighting the opportunities to use BIM as a tool in designing for safety (Ku & Mills, 2010, Gabatese, 2004), less work has been done assessing opportunities to use BIM to improve safety training material. As a 3D visualization tool, BIM enhances communication and understanding regardless spoken language. Superior visualization may prove particularly relevant when developing safety training material for Hispanic workers where language barriers may exist. However, BIM has capabilities beyond visualization, and its added functionalities provide additional benefits in the development of safety training material. This paper outlines how the authors have been using Adobe Captivate to develop training materials featuring a simulated BIM model augmented with written and audio annotations. The result is multi-modal instruction material following guidelines for educational materials targeted to Hispanic workers. Building on existing research for construction management education in general (Clevenger et al, 2010), the authors hope to prove such training material is significantly more effective in training Hispanic workers.

Future developments will build on the information integrated into BIM models and will include the creation of interactive training and assessment material. BIM provides the ability to demonstrate a sequence of operations. Dynamic 4D animations are valuable in illustrating certain safety strategies, and surpass the capabilities of static visualizations. BIM also provides the opportunity for automated assessment. Workers who are being trained will be asked to sequence or interactively identify certain pieces of safety equipment and/or equipment heights or dimensions. Since BIM stores such information in the model, BIM enabled training material can provide feedback on worker interactions with a model, or be used to assess their general level of knowledge by asking questions regarding specific safety controls. This enhanced ability to automate and assess workers may also prove particularly important for the Hispanic population of workers where assessment has historically been challenging.

Conclusions

Initial training module development and implement produced finding that suggest 3D visualization can be an effective tool to train a diverse population if guidelines are followed to ensure that the approach in language is culturally appropriate. Therefore, we believe that using 3D visualization to train construction workers meets the intent of the standards policy statement memorandum issued by OSHA. This paper focused on developing a training program in Spanish for Hispanic workers. The program can easily be modified for other languages and cultures if a native speaker who has in-depth knowledge on the topic translates it. This training method may serve as a powerful education tool in safety instruction. In particular, by following guidelines developed for educational materials targeting Hispanic workers, the method is likely to be highly effective across language and culture. Furthermore, if a 3D model is available or being developed for other purposes on a project developing implementing a customized training program does not require a significant amount of additional work. Companies will likely increase their workers' safety awareness and reduce the number of accidents in their jobsites by using 3D models to provide better safety and construction processes training.

Future Research

The next phase of this research will consist of conducting a pilot test of the wall assembly model with Spanish speaking construction workers. Construction companies in Denver, Colorado with established relationships with the Department of Construction Management at Colorado State University will provide access to jobsites to conduct pilot testing. In addition, the authors have been awarded funds from the United States Agency for International Development (USAID) to develop and implement a green construction training program for laborers in Tijuana, Mexico. The authors will adapt and utilize the 3D visualization modules to enhance safety training in Mexico and will use the opportunity to further test the modules. Thirty Spanish speaking construction workers on jobsites in the United States and Mexico will be selected. Participants will be divided into two groups. The first group will be the control group and will receive the typical instruction regarding safety related to wall assembly construction. The second group will be shown the 3D module in addition to the typical safety instruction. A pre-test, post-test and a follow up survey will be administered to participants to identify and evaluate their level of understanding regarding safety practices in wall assembly construction. The results will be used to fine-tune the module and identify future opportunities to enhance safety training for laborers.

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