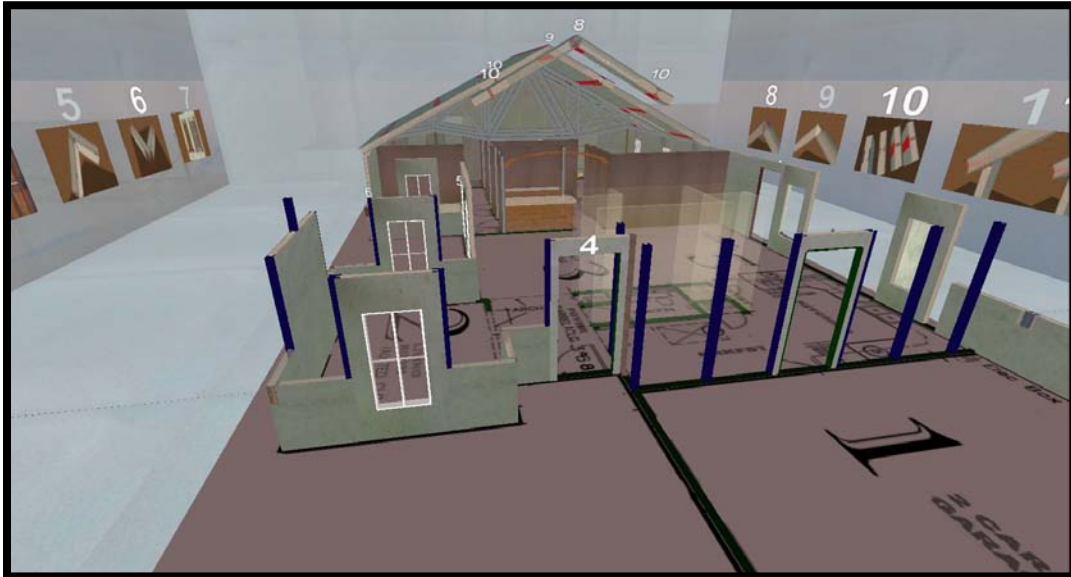


Building Inspector Virtual Training Pilot



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This report has been prepared for Lawrence Berkeley National Lab and the Department of Energy as the deliverable for Task One of the FY2009 FAS Scope of Work, which tasked FAS with creating an online tool to improve understanding amongst building inspectors on code compliance and constructability issues for advanced building systems and to give inspectors a baseline understanding of building energy performance concepts.

This report summarizes existing training methods and tools for building inspectors and code officials, concluding that they are inadequate to meet today's pressing need for housing that is more energy efficient and sustainable. Virtual tools are a promising solution to these training inadequacies due to many factors, including their interactive nature and capacity for remote collaboration and learning. In order to assess this virtual training concept, FAS has created a pilot program to train building inspectors on energy efficiency and thermal tightness concepts and on how to inspect a residential building constructed with Structural Insulated Panels (SIPs). The results of this pilot, including lessons learned and recommendations for future virtual training development are included in this report.

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Introduction and Explanation of Training Gap

With the building sector using more energy and more electricity than any other sector in the United States,¹ this sector must become vastly more energy efficient and sustainable if the nation is to reach its carbon reduction goals. In 2008, the residential building sector alone was responsible for almost 22% of the nation's total energy consumption.² Through both retrofits of existing houses and through building more efficient new houses, there is great opportunity and potential for energy savings within the building sector. However, achieving these energy savings will require utilizing advanced technologies, materials, and systems that increase building envelope tightness, waste less energy, and improve building comfort and security for occupants.

One of the key barriers to the wide-scale adoption of energy efficient, high performing materials, practices, and technologies is a lack of education and training. Professionals and tradesmen often do not know to design with, install, or inspect these advanced materials and technologies, which therefore are infrequently used and when utilized, do not perform optimally due to installation errors. In order to facilitate their adoption and take advantage of the capabilities of these advanced products, training must be improved throughout the industry; without this improved training they will neither achieve significant market penetration nor achieve their energy efficiency potential.

The Federation of American Scientists has worked closely with manufacturers of and industry professionals who work with structural insulated panels (SIPs), a high performing and energy efficient building system. SIPs can be used for walls, flooring, and roofing and serve as an insulator, structural support, and weatherproof barrier; they are structurally strong, have high thermal resistance when properly installed, produce little waste as they are manufactured and cut in the manufacturing plant, and are installed quickly and with fewer labor hours than a traditional stick framed structure. Despite possessing these many positive attributes, market uptake of SIPs has been minimal. Manufacturers and representatives of the Structural Insulated Panel Association (SIPA) note that building inspectors and code officials are frequently neither familiar with SIPs inclusion in the International Residential Code (IRC)³ nor inspecting SIPs for proper installation. In order for SIPs to be widely adopted by the building industry and in order to ensure that code compliant and efficient installation occurs, improved SIP training tools for building inspectors are needed.

¹ Architecture 2030 estimates that in 2000 the building sector (including residential, commercial, and manufacturing buildings) was estimated to account for 48% of the nation's energy consumption and 76% of the electricity consumption.

Architecture 2030, "The Building Sector: A Hidden Culprit,"

http://architecture2030.org/current_situation/building_sector.html (accessed September 28, 2009).

² Energy Information Administration, "Table 2.1a: Energy Consumption by Sector, 1949-2008," *Annual Energy Review 2008*, <http://www.eia.doe.gov/emeu/aer/contents.html> (accessed September 28, 2009).

³ SIPs are included in the 2009 *International Residential Code*, Section R613.

International Code Council, *2009 International Residential Code For One- And Two- Family Dwellings*, (USA: International Code Council, Inc., 2009), 348-356.

Current Industry Training Methods

The International Code Council (ICC), American Society for Heating, Refrigerating and Air Conditioning Engineers (ASHRAE), American Society of Home Inspectors (ASHI), National Association of Home Inspectors (NAHI), Institute for Building Technology and Safety (IBTS), and private and state/municipal training organizations all offer building inspector courses to train potential and current inspectors on understanding and inspecting for code compliant building practices. And while numerous organizations offer training programs, certification to become a certified building official (CBO) can only be given by either the municipal/state government or one of the major CBO organizations, such as the ICC or ASHRAE. These two organizations, in addition to certifying CBOs and holding certification exams, also offer courses that train building officials either to pass the exam or for the purpose of continuing education. Most of courses and seminars offered take place primarily in the classroom and emphasize a format of instructor lectures and student memorization of key codes and code concepts. In the classroom instructors use tools such as code books, written materials, and media such as videos and CDs to aid students in learning content.

In addition to classroom time, many courses include time in the field (usually no more than one day) learning how to do an inspection from an experienced instructor. Courses taken in order to prepare for a certification exam, such as the ICC's Residential Building Inspector certificate exam, almost always include both the classroom and field elements as students must both pass a written examination and a field examination, thereby proving both their knowledge of codes and related concepts and their ability to actually perform an inspection. In recent years both the ICC and ASHRAE have begun to offer online training courses as an alternative to the physical classroom; these courses are referred to by the ICC as eTraining or as ICC Online Campus courses and by ASHRAE as eLearning courses.⁴

These instructor-led online courses or “webinars” cover nearly identical content to and follow a nearly identical format to the non-web courses, with an instructor lecturing and teaching to students via video streaming and the students interacting with their instructor and asking questions in the online training environment. In addition, students can take independent online training courses; these courses consist of reading a section of the code or an explanation of an important concept, then answering problem solving-style questions that utilize graphs, charts, and other media related to code concepts. Full-length web-based practice exams are also offered to assist in reviewing course material. Collectively, the existing web education capabilities consist of virtual lectures and seminars; making written materials available, including code sections and summaries; online practice exams; and online independent courses that educate students about codes and code concepts through limited interactivity, written material, and media (i.e. videos, photos, and interactive charts and graphs).

However, very little of the virtual content actually prepares students to be building inspectors. They are not shown how to do a walk through; they are not able to practice comparing actual construction to structural and architectural plans; they cannot simulate interacting with the parties involved in an inspection; and the interactive features are in reality little more than a picture or graph that, when clicked, pops up a one sentence explanation of the content. And while webinars allow the instructor and students to verbally communicate and the students can see the instructor via video feed, the instructor cannot simulate an inspection or show the details or plans being discussed, and the opportunity for social interaction is highly limited. Moreover, the training structure is almost entirely

⁴ International Code Council, “ICC Campus Online,” <http://www.icccampus.org/> (accessed September 28, 2009). American Society of Heating, Refrigerating and Air-Conditioning Engineers, “ASHRAE eLearning,” <http://www.ashrae-elearning.org/> (accessed September 28, 2009).

based on verbal and written memorization and regurgitation, with little opportunity for kinesthetic learning and little thought given to improving the understanding and application of knowledge by encouraging transfer¹.

To develop a workforce of inspectors who understand both the need for energy efficient advanced technologies and how the code applies to energy efficient technologies and materials, training needs to be more interactive, provide opportunities for kinesthetic learning, promote transfer, transcend geographical limitations, and be structured as an integrated program that weaves together written curriculum content and field exercises and training.

Virtual Worlds and Web 2.0

The tools of web 2.0 and the latest iterations of virtual worlds possess the capabilities to carry out advanced, remote, and highly interactive simulations, trainings courses, and educational seminars and demonstrations needed by the building industry.

Current State of Virtual World Industry and Development

Estimates by Gartner, an information technology research consultancy, project that by 2011 80% of active internet users will have a virtual world avatar in some virtual world. This represents a significant market penetration rate and signifies that by utilizing virtual worlds, trainers and educators will not be introducing students to an unknown technology, but rather introducing new content through a known and understood medium.⁵ This medium has been used by both the corporate and education worlds to hold meetings, conferences, and classes, to collectively work on projects and bring together experts from different places, and to network and socialize. At Harvard University, for example, students can earn credit for a course attended in a virtual classroom. And at Intel, conferences and meetings are often held at the virtual Second Life conference room. Research by the Palo Alto Research Center indicates that group interactions and teamwork, psychological responses, and learning within the Second Life world closely mirror that in the real world; as such, training and simulation modules that are designed to be interactive, hands-on, and mimic real-life scenarios can yield mental retention and learning similar or even equivalent to that of the real-life scenario.

To assess this theory and the value of virtual worlds in training adults to master complex skills, content, and scenarios, medical schools and health care facilities have begun to utilize virtual worlds as state-of-the-art, interactive, and highly realistic training environments.

The Imperial College London, for example, has built a virtual hospital in Second Life. The hospital includes a virtual operating room, where students practice treating patients and dealing with common emergencies and operations, and a Virtual Respiratory Ward, where students test their knowledge of respiratory problems by interviewing, diagnosing, and recommending treatment for patients. While the medical field has used simulations for years via dummy operating and treatment rooms and software-based SIMs, early adopters note that the primary advantages of virtual world clinical training are: the ability to bring geographically distant people together for the simulation, the low cost, and the ability to simulate otherwise impossible or unsafe situations. In using a virtual world, training programs can bring experts from around the world into one clinic to teach students and lead post-op discussions, while

⁵ Gartner Inc., "Gartner Says 80 Percent of Active Internet Users Will Have A "Second Life" in the Virtual World by the End of 2011," <http://www.gartner.com/it/page.jsp?id=503861> (accessed 28 September 2009).

allowing students to network and discuss their work, all at a much lower cost than bringing all parties into the same physical clinic. Scott Diener of the University of Auckland notes that “We tested [the virtual O.R.] in a controlled experiment on 40 first-year medical students prior to their first visit to a real O.R. We wanted to determine if [the SL program] gives them more confidence before their first exposure to the real thing. We’ve found it is just as effective as the training O.R. in the physical world.”⁶

Diener also emphasizes that virtual world simulations can expose students to situations that a standard academic program cannot duplicate: “[SL] is not about creating an automated teaching environment. It’s about giving students experiences we can’t give them otherwise, because it’s impossible or unsafe.”⁷ Thus, while there is not a great deal of empirical evidence as to the effectiveness of Second Life as a training platform, initial studies by medical schools indicate that there are advantages to using virtual worlds over both classroom instruction and physical simulation in terms of the convergence of low cost, access to experts, and scenario-based simulation.⁸

The virtual world environment is currently the only means by which to bring people together in an interactive environment without necessitating any physical travel. This capability, one of the most important, reduces training expenses as building a virtual world simulation and putting participants in that scene costs a fraction of what it costs to build a real world simulation and transport participants to the site. Within the immersive environment participants can network, socially interact both verbally and face to face (or rather avatar to avatar) and can work together to solve problems or simulate real-life scenarios, just as they would be able to in the real world.⁹

In terms of the building industry, potential simulations could include participants building or designing housing components or entire houses as a team, being shown new technologies and techniques by industry experts, reviewing or assessing a built structure, or inspecting the structural problems that led to the destruction of a virtual building in a post-disaster simulation scenario. And as people intellectually and emotionally react similarly in both the physical and virtual worlds, the virtual world can be effectively used to familiarize students with concepts, places, and situations they will encounter in the field, but have never previously experienced. As a result, in the physical world the learning curve is shortened and problems encountered can be dealt with not as new experiences, but as previously encountered and solved problems.

Second Life

Second Life specifically is a useful training environment as it is currently the largest and most comprehensive virtual world. From building objects and avatar interactions to modeling energy or water flows, leakage, and thermal resistance, Second Life is at this point the world wherein the most advanced and realistic whole building modeling and simulation can be done. In addition, under the training model currently employed by ASHRAE and the ICC participants pay to take both courses and to take the certification exams; with Second Life Grid platform and Second Life Work (the version of

⁶ Melissa Lafsky, “Can Training in Second Life Teach Doctors to Save Real Lives?” *Discover Magazine* (2009), <http://discovermagazine.com/2009/jul-aug/15-can-medical-students-learn-to-save-real-lives-in-second-life> (accessed September 28, 2009).

⁷ Ibid.

⁸ Citation from Sachin on scenario-based learning

⁹ Greg Wadley and Nicolas Ducheneaut, “The ‘out-of-avatar experience’: object-focused collaboration in Second Life,” (paper presented at the European Conference on Computer-Supported Cooperative Work, Vienna, Austria, September 7-11, 2009), <http://disweb.dis.unimelb.edu.au/staff/gwadley/roc/ECSCW09-WadleyDucheneaut.pdf> (accessed September 28, 2009).

Second Life targeted toward corporate, government, and education users) training organizations need not alter their revenue model as the professional edition allows owner to keep their property and content behind a password protected firewall. Though the behind-the-firewall option is currently in beta form, it will allow property owners to limit access to all or part their properties, thereby allowing a training space to be accessible only to registered users for a specific period of time. For example, in signing up and paying for a building inspector course trainees would be paying for access to a particular training environment for a set period of time (such as 90 days) in order to participate in the formal training course, then continue to use that same environment to practice and enhance the skills and knowledge learned from the instructor.

Virtual World Adoption Barriers

There are key issues that at the present time inhibit the large-scale adoption of virtual worlds as a tool for business and education. The primary problem is the lack of interoperability and compatibility between virtual worlds. An object built in Second Life, for example, cannot be exported into another world and vice versa; with different coding languages and data formats, despite the open source nature of coding languages (referred to as Linden Scripting Language in Second Life), content and language can only be shared within that limited world. Industry analysts therefore recommend against making huge monetary investments in virtual worlds until such a point that the various platforms are compatible. However, while large-scale investment in one platform for commercial purposes is unwise until such a point that virtual worlds are compatible or integrated, this logic does not as readily apply to education. For the purposes of education and training, the cost savings of training in a virtual world environment is immediate and ongoing and the objective is to use the environment as a tool for educating and training an audience acquired through non-virtual means rather than to meet the commercial objective of promoting a product or brand image to potential customers encountered within the virtual world.

A second barrier to virtual world business and education adoption lies in that each user must have Internet access, computer access, and basic familiarity with operating within the virtual world as well as its functions and capabilities. Without reliable Internet and computer access, participants cannot take advantage of any virtual world training and without a basic virtual world familiarity, participants must undergo an additional orientation and adjustment period while learning how to operate and function in a virtual world. The necessity of learning these new virtual world skills in addition to the course content may deter some potential participants from utilizing this new training platform. However, according to the 2009 Digital Future Report by the Center for the Digital Future, over 80% of people in the United States now use the Internet and only 15% of homes do not have a computer. Of the Internet users, over 80% connect have a Broadband Internet connection.¹⁰ Thus, lack of reliable Internet and a computer is becoming increasingly less of a barrier. When these figures are coupled with the estimate by the Gartner Group that 80% of Internet users will have a presence in non-gaming virtual worlds by 2011, it is apparent that the majority of the working age American population has familiarity with the Internet and at least a basic familiarity with virtual worlds that will rapidly grow over the coming years.¹¹

¹⁰ Center for the Digital Future, "Digital Future Project Release Highlights," 2009, http://www.digitalcenter.org/pdf/2009_Digital_Future_Project_Release_Highlights.pdf (accessed September 28, 2009).

¹¹ Anders Gronstedt, "Virtual World Learning," *Training Magazine* (2007), http://www.salesandmarketing.com/msg/content_display/training/e3icb706624eaa6b047f367f6c5ec543baa (accessed September 28, 2009).

Anders Gronstedt, "Training in Virtual Worlds," *Training Technology and E-Learning*, Iss. 0803 (2008).

At present, there is no simple mechanism by which to connect virtual worlds to outside resources and data. Objects can be linked to outside web sites, but creating a library of information, supporting resources, media, learning activities, and assessments, then gathering all of that content into one organized, easy to understand location is not possible in the virtual world. This ability to organize and link materials and content to the virtual world is a necessary feature for most trainers and educators as the simulation in the virtual world is not a stand alone, but a key component of a larger curriculum. In the case of training building inspectors, the virtual scenarios and instructor-led sessions are a component of a course that needs numerous components to be effective, including materials such as exam preparation documents, practice exams, and code books, and tools such as media, discussion forums, architectural CAD images and structural and engineering drawings.

As such, in order for virtual worlds to become an effective and widely used learning environment, they must be integrated with a simple, user-friendly platform with features including, but not limited to: materials storage and organization, curriculum and content explanations, wiki and forum integration, and assessments and assessment results storage. Through integration of such a platform with virtual world training environments a truly interactive, immersive, innovative education and training tool can be created.

Medulla

In order to solve the issue of the inability to easily integrate virtual worlds with outside resources and data, the FAS has created Medulla, an independent platform that weaves together virtual worlds and web tools. The purpose of Medulla is to allow:

- a. collaboration among users across virtual worlds, Medulla tools, and third-party tools including commercial web applications;
- b. interoperation between two independently hosted web applications irrespective of their internal composition; and
- c. creation and archiving of content in virtual worlds that is viewable and searchable on the web (for further details on the functionality and purpose of Medulla, see Appendix 1).

Specifically, Medulla weaves together tools such as digital archives (DSpace), wikis, virtual worlds, and digital media such as videos and photos and organizes them in an open source, easy to navigate template. This template allows the project manager to tailor the template for the target audience, writing descriptions and learning objectives for the training module as a whole as well as individual scenes and objects within the immersive training environment; link each template (including its written content and supporting materials) to a virtual world or multiple virtual world scenes; create and post learning activities and scenario guides; and organize references, media, learning activities, and supporting materials into categorized group boxes. In addition, all registered users can upload files to the group boxes and edit the project's wikis, allowing users to learn from and contribute to an interactive and constantly evolving project that works with and within the virtual world and gathers the curriculum and learning content into one simple template.

The Building Inspector SIP Training Module Pilot

Utilizing the Second Life virtual world and the Medulla web platform, FAS has created a pilot project to test the feasibility of training building inspectors in the virtual world. The specific goals of this project are to ease the adoption of advanced building technologies and to improve training related to energy efficient construction and advanced technology in the construction industry. The pilot also seeks to improve understanding of code compliance and constructability issues among building inspectors and

code officials. More broadly, this pilot seeks to teach residential building inspectors how to properly inspect a home built with SIPs by educating and then assessing the trainee on code compliance issues with SIPs, common installation errors, and energy efficiency concepts. A highly flexible training tool, the virtual world environment can be used in formal instruction, to independently learn practice inspecting, to expand conceptual knowledge of energy efficiency and SIP concepts, and for self-assessment. As such, virtual world space has been designed with the goal of providing an intuitive and interactive learning environment that is highly flexible and connected to relevant, engaging, and educational materials and media.

Summary of Training Module Functions and Components

In this module, the SIP training and assessment primarily occurs within the Second Life virtual world, with additional content, supporting material, and training tools hosted on Medulla. Key topics covered by Medulla content include: the purpose and goals of the training module; background on how Medulla and Second Life work and interact; how to function within the Second Life world; the capabilities of the training environment and virtual world; scenarios for independent and instructor led education; skills that the trainee will acquire; information on SIPs and constructing and inspecting SIP houses; and detailed data about key components of SIP architecture and engineering. This information is provided to users by through a variety of mediums, including text, images, architectural and structural drawings, video, and models of real and virtual SIP structures.

The Building Inspector SIP training area is broken into three primary components: the Introduction and Orientation area, the Training House area, and the Assessment House area. The objective of the Introduction scene is to familiarize users with Second Life, provide information on SIPs and introduce users to SIP fabrication, materials, and installation, and provide a brief overview of key concepts in energy efficiency.

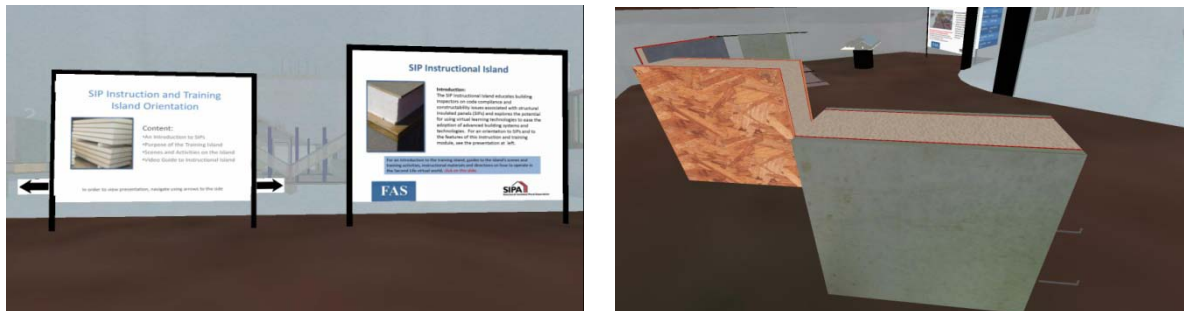
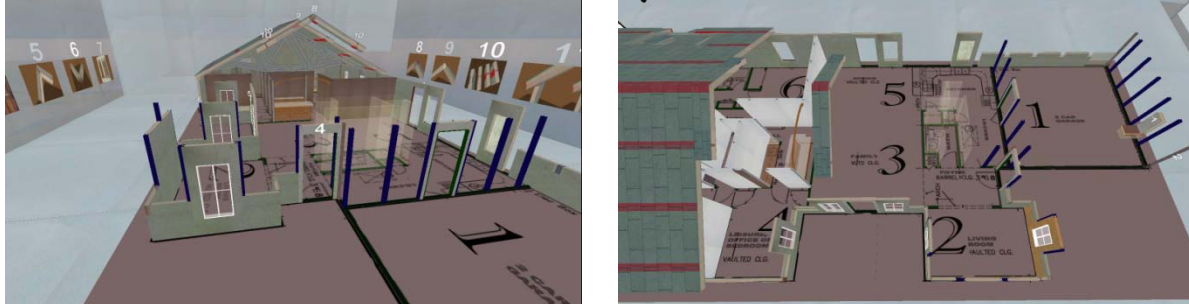


Figure 1. Introduction and Orientation Scene: billboard, presentation, and SIP models

Users begin their exploration of the virtual environment in the Introduction and Orientation area by linking to the necessary “how to use this module” documents on Medulla (included as Appendix 2) and watching a presentation on SIPs and energy efficiency. After watching the presentation users explore the Introduction and Orientation area with the aid of the “Scene 1 Activities Guide,” (see Appendix 3) which includes animated models of SIPs and SIP construction techniques, learning materials, and information about SIP fabrication and installation. Once the user has thoroughly investigated this introductory scene, the user moves onto that main instruction scene, the Training House.

In the Training House scene users encounter a SIP demo house modeled off of the architectural drawings of a real SIP house. This house represents multiple stages of construction from laying the foundation to installing exterior cladding. At each stage the demo house demonstrates proper installation techniques and materials use, emphasizing safe construction and tightness of the building

envelope. Throughout the house nineteen construction details are marked with white numbers; each of these is a detail commonly installed improperly or around which there is frequent confusion regarding proper installation and sealing/insulating. In order to find out more about that particular detail the user simply clicks on the white number above the detail and is taken to the Medulla site, which houses a description of the detail and common installation mistakes, CAD images of the detail, and screenshotsⁱⁱ



showing the detail. As a complement to the Training House, the adjacent Gallery indexes screenshots of each detail, allowing the user to visually review the details in the house. And as with the Training House, in order to obtain more information about or CAD images of a detail the user clicks on the number and is directed to the appropriate Medulla page.

Figure 2. Training House Scene: Training House and Gallery

Users spend the majority of their time in the Training Demo House as this scene is where the majority of instruction, independent investigation, and learning take place. Either with the aid of the written “Scene 2 Learning Activities Guide” (included as Appendix 4) or with a building inspection instructor, trainees are led through a simulated inspection of the Training House’s structural elements, SIP connections, roofing connections, electrical, and plumbing. While the “Guide” and supporting materials contain a great deal of information, to take full advantage of virtual world capabilities such as asking questions and receiving immediate feedback, socializing or networking with colleagues and the instructor, and collectively troubleshooting problems, a formal, instructor-led walk-through is necessary. Once the mock inspection has been completed, trainees can independently practice inspecting a house on their own, and explore SIP construction and energy efficiency both in Second Life and through the reference materials in Medulla. In addition, if students have questions about a particular component encountered in the Training area or wish to discuss building, training, or inspection-related issues with their colleagues or an instructor, this scene is linked to an open wiki.

In the final Second Life scene, the Assessment House scene, users test their knowledge of SIP construction techniques and concepts. The specific objective of this scene is to allow students to apply the information, process, and principle-based knowledge gained through the mock inspection and investigations of the Training House. To this end, the scene contains a house nearly identical to the training house except in that of the nineteen details from the Training House ten have been constructed improperly, compromising either the structural integrity or tightness of the building envelope. Each mistake was deliberately made to mimic a mistake commonly made by SIP installers in the field. A self-assessment mechanism, this scene contains both knowledge-based and principle-based multiple choice questions that the student answers and received immediate feedback on. Where the student does not answer a question correctly, that student is encouraged to visit the corresponding informational materials on Medulla to improve their understanding of that particular concept or proper construction component.

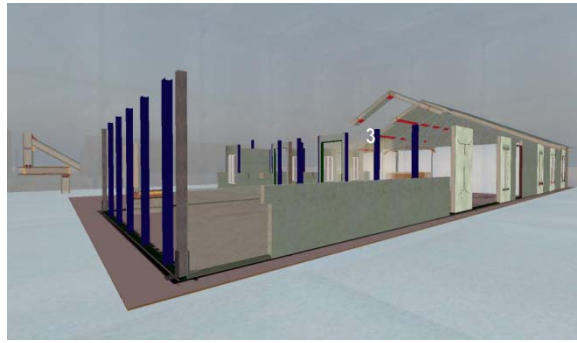


Figure 3. Assessment House Scene

One informational question, for example, asks:

“Correctly identify the mistake in this detail. A) There are no mistakes. B) There is no flashing. C) The panels are not correctly screwed together. D) The cladding is not ventilated.”

And further into the house users are presented with the conceptual question: “The electrician has cut channels for wires in the field. Did the electrician wire the house correctly? A) Yes. This is the correct procedure. B) Yes. It is not standard procedure according to the manufacturer’s directions, but is a widely accepted method of wiring a SIP house. C) No. Cutting into the SIP exposes toxic insulation. D) No. Cutting into the SIP compromises its R-value.”¹²

A highly adaptable scene, the assessment house and questions have been designed to be easily and quickly modifiable, allowing the house to serve an ongoing educational purpose. By changing the details to illustrate different mistakes and creating new conceptual questions, new assessments can be continually developed to further address the continuing education requirements and desires of current building inspectors.

Advantages of this Virtual World and Web Training Pilot

Though dissemination of this pilot has been minimal, industry experts have explored and offered feedback on the training module’s virtual world content and the Medulla-based training guides and reference materials. Initial feedback of this pilot has validated many of FAS assumptions regarding the advantages of virtual world web training over classroom or current webinar courses. As determined by feedback, the primary advantages are: the capability to show 3-D, highly detailed, architectural and structural details; the connectivity between the virtual world components and related information, data, and CAD images; the ability to demonstrate code compliance features and issues in a relatively inexpensive and time efficient manner; and the ability to collaborate, instruct, and train remotely.

In order to assess the remote instruction and education potential of this pilot we gave basic instructions to industry professionals, asking them to use our Second Life Orientation guide to create a Second Life account, login to the Medulla platform and Second Life, and explore the Training Module independently. We then went through the training module with the same group, discussing features, critiquing the details in the training house, and discussing potential operability additions to the virtual world. While users had minor to substantial trouble acquiring a Second Life account and creating an avatar and recommended we devise a simpler method of accessing the virtual world environment, once logged in the users found the environment to be highly useful for independent study of codes and energy efficient building materials and concepts. The building details and animations especially were found to aid the user in understanding proper construction techniques, while the interactive links to Medulla were found to be highly useful in learning conceptual material.

¹² Federation of American Scientists, “Building Inspector SIP Training Pilot,” in Second Life virtual world, 2009, <http://slurl.com/secondlife/FAS/147/49/27> (accessed September 28, 2009).

Our subsequent group walk-through convinced users of the advantage of this virtual world for formal instruction, allowing instructors to present specific scenarios and demonstrate the process of inspecting, while simultaneously allowing trainees to interact with one another and the environment. Moreover, both instruction and independent exploration can be both highly tailored to the needs of the target audience and experts can be brought in to teach courses regardless of the geographical location of the expert or the students. While initial feedback indicates that minor changes and additions to both content and interface must be made prior to the Training Module's adoption on a large scale (feedback is further discussed below), this method of training possesses significant advantages over existing training methods.

Lessons Learned from Creating Building Inspector Training Module

Through creating this pilot training module and introducing building professionals to the module, FAS has learned key lessons relating to the process of training module development as well as how to improve and update the course and virtual world.

Building in the Virtual World

In a virtual environment where the detailing and scale is essential, such as in the Training House, building within the virtual world can be an arduous process. For complex and detailed models and building components, building in the virtual world is not always ideally precise and textures cannot be tested on an object before they are imported. Instead, creating components in an architectural CAD or 3D sculpture modeling program and then importing them into the virtual world yields more precise components that better match the specified architectural and structural plans. In addition, it is necessary to partner with suppliers and manufacturers of raw building materials in order to obtain properly detailed images and textures for architectural models. These manufacturers are also an excellent resource from which to obtain the detailed specification drawings necessary to make 3D models as well as the engineering data on various materials and joints or connections.

New User Orientation

Developing virtual building inspector training on a large scale will require easing the adoption of this new training tool for those without high computer literacy. Currently, the Training Module has a written introduction on how to use the virtual world, create an avatar, etc. However, this virtual world orientation process must be made simpler for the inexperienced user. One possible method of simplifying orientation would be to use video, a familiar and widely-known medium, to show new users how to sign up and create an avatar or operate an existing avatar. A second method would be to create premade training avatars that, when coupled with an auto-logon feature, would altogether eliminate the need to create an avatar and log into the virtual world.

Virtual World Content

Expansion of content and stronger integration with web tools is essential to building a successful virtually-based training module. As the primary training mechanism, the virtual world must have multiple environments that can be utilized either individually or collectively to meet different training objectives for different audiences. In order to make the most useful training environments possible, it is necessary to register all models as open source and to take advantage of the object copying capabilities of the virtual world; with these two capabilities all houses in the module can be built from the same

base model and then altered to meet the specific requirements of professional audience and local code (i.e. structural engineers and inspectors in California). Using the same base environment, with highly similar conditions, drastically reduces the programming costs of module expansion and enhances the ability of users to gain and retain new knowledge.ⁱⁱⁱ

Within this immersive environment, each object and each scene must be highly interactive, requiring the user to manipulate the environment in order to gain additional knowledge. Within the current training module each building component of the Training House is moderately interactive in that to learn about that detail you must click on it; in addition, the Orientation area contains some avatar-controlled animation and models. However, navigating the Training House does not at present require the user to manipulate any objects within the scene and research shows that requiring avatar manipulation or enabling the “what if?” element of cause-effect interactions improves knowledge transfer and retention.¹³

In addition, there is currently limited capacity for kinesthetic-based problem solving (i.e. the user virtually building or altering some component of the house) and this kinesthetic oriented content is needed in order to bring together the classroom learning with the hands on field learning. To meet this goal of weaving together written content and field practice, future building inspector virtual training modules must have multiple learning scenarios and simulations for each scene and each audience. These scenarios and simulations should be engaging, have focused objectives, and be limited to a small area of the environment (1-2 scenes) in order to not overwhelm the user and to focus attention on learning material not exploring. Well-designed scenarios can model real life experiences and situations, resulting in better prepared and more capable inspectors and building professionals.¹⁴

And finally, the virtual world content must be strongly linked with a curriculum and toolset that is housed outside of the virtual world in an independent web platform. Basing tools and curriculum content in the virtual world requires relying upon the virtual world developers to update technical capabilities and fix interoperability barriers, which is not an ideal solution due to the limitations previously discussed. Rather, hosting course materials and toolsets on an adaptable, user-friendly template in an outside web platform overcomes the limitations of the virtual world and allows for greater control over the tools, course and material organization, and degree of immersion in the virtual world.

Recommendations and Next Steps for Virtual Training

FAS recommends that the next step toward meeting the goal of improving training for building inspectors and code officials be the creation of a comprehensive training module and correlating small-scale training program. This comprehensive module must include both an immersive virtual world training environment and web-based toolkit and must incorporate the lessons learned from this initial pilot.

¹³ M. Suzanne Donovan, John D. Bransford, and James W. Pellegrino, eds., *How People Learn: Brain, Mind, Experience, and School: Expanded Edition* (Washington, D.C.: National Academies Press, 2000), http://www.nap.edu/catalog.php?record_id=9853 (accessed September 28, 2009) 51-78.

¹⁴ Ruth Clark, “Accelerating Expertise with Scenario-Based Learning,” *Training + Development (T+D)* (2009), <http://www.clarktraining.com/content/articles/ScenarioBasedLearning.pdf> (accessed September 29, 2009).

In order to create a high quality training module, the curriculum development and architectural modeling must be done in partnership with industry experts, including structural engineers, architects, and materials representatives or manufacturers, code officials/building inspectors, and private code organizations such as the ICC and ASHRAE. This will allow the virtual environment, simulations, and scenarios to represent the physical world as closely as possible and will enable the virtual environment and toolkit to integrate energy efficiency concepts via energy flows modeling.

Within the virtual environment, the prototype virtual house must be built to the specific code of one state or municipality, allowing the house to be used as a realistic training tool for the building inspectors and code officials in that area. This house should have expanded functionality over the pilot Training Demo House, including the capability to model energy flows within the house, greater interactivity that includes the ability to manipulate the house's materials and construction, and the addition of problem solving activities and scenarios.

FAS recommends that the next iteration of the training module focus primarily on developing the platform of tools outside the virtual world environment. At present, the state of virtual world technology is such that it cannot be easily integrated with web-based tools and virtual worlds lack interoperability with one another. In order to compensate for these technological gaps and enable large-scale adoption of immersive web training, an independent platform is needed to house tools, materials, and other training content. This platform must have a template that is intuitive and straight forward, with the capacity to be flexible and expandable as training courses and tools are added.

In addition, there must be greater integration of the virtual world with web-based tools and content; to this end the virtual world should not be seen as the primary training platform, but as a tool for immersive learning, scenarios, problem solving, and processual learning within the larger, independent training module. Focusing on building and expanding the learning module's content and courses will allow multiple activities for multiple audiences to utilize the same virtual world scene. This capability will, most importantly, save money due to reduced virtual world development costs. In addition, the environments for related courses will appear nearly or completely identical, shortening the user's learning curve as the environment need not be re-learned and re-explored for every new course or simulation. If a building inspector were to take a course of formal instruction, for example, the environment in which the course takes place would look almost identical to those in which the inspector practices inspecting via virtual scenarios and independently studies the course's concepts. The scenarios, formal course, and independent exploration would all utilize different tools and templates within the independent platform, but the same virtual world environment.

A final recommendation for future virtual training development relates to deployment strategy. In order to assess the feasibility of large-scale virtual world training for inspectors, a small-scale training pilot must be carried out to train approximately 100 students in how to inspect an energy efficient, code compliant house that uses advanced materials and building systems, such as SIPs. Recruiting participants and gaining buy-in for the technology requires utilizing existing partnerships with current code certification organizations, construction-related certification programs at schools and institutes, local or municipal-level building code offices, and adult education programs. With input from these partners, the learning module, the virtual world environment, and the web-based tools can be assessed and improved. And assuming the pilot virtual training course demonstrates greater success than a traditional course, a full-scale deployment strategy can be developed to create a virtual training program that trains, assesses, and certifies existing code officials to inspect residential buildings that have energy efficient features and advanced technologies.

Conclusion

In order to meet our nation's energy efficiency goals thousands of construction professionals will need to be trained in how to design with, build with, retrofit, and inspect energy efficient and technologically advanced buildings. Doing so requires that training move beyond classroom based and simple web-based methods and tools currently utilized. Training must utilize advanced web tools and immersive virtual world training in order to teach building professionals content, process, and concepts in an efficient, dynamic, and inexpensive manner. To this end FAS recommends the development of web-based learning modules and corresponding pilot training programs in order to assess the utility of virtual world training and to begin the process of training workers for a greener, more energy efficient, building industry.

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Appendixes

Appendix 1: About Medulla

Appendix 2: Learning Activity 1 “Second Life Orientation and Practice Guide”

Appendix 3: Learning Activity 2 “Learning Activities for Scene 1”

Appendix 4: Learning Activity 3 “Learning Activities for Scene 2”

ⁱ Transfer is the process that occurs when “learning in one context enhances or undermines a related performance in another context” (Perkins and Salomon 1992). The purpose of building transfer into learning is to promote students’ ability to recall earlier information, understand how the new material being learned relates to earlier information and to the larger concept, and to apply that understanding in future situations (Donovan, Bransford, and Pellegrino 2000).

In seeking to promote the transfer of learning, it is essential to note that not all learning is equally transferable in all situations. Educators separate transfer into far and near categories, with the near occurring in those situations where both contexts possess numerous identical elements and components. For example, an instructor teaches a student how to solve a math equation in the classroom and then the next day teaches that student how to solve a similar, but more difficult math equation in the same classroom, using the same method. This example demonstrates an extremely close form of near transfer as the two contexts are only minimally different. Far transfer is more difficult to achieve and requires a more in depth understanding as it occurs in situations where the two contexts are vastly different. Taking learning from the classroom out into the real world exemplifies far transfer as almost every element of the context is different and so a deep understanding of the material and its underlying principles is required in order to solve problems or handle scenarios in the different context. Because enhancing learning through transfer is easier in similar contexts (near transfer), it is more effective to train students in an environment similar to the one in which they will be performing the tasks in real life.

ⁱⁱ The term screenshots in this case refers to photographs taken by an avatar’s camera of objects or scenes in Second Life. In the case of Medulla, screenshots are used to aid the user in matching the description with the specific object or objects described.

ⁱⁱⁱ This enhanced knowledge acquisition and retention capability is explained through the theory of low road and high road transfer. Low road transfer is reflexive and triggered by “well-practiced routines by stimulus conditions similar to those in the learning context” and high road transfer is mindful and triggered by “deliberate effortful abstraction and a search for connections” (Perkins and Salomon). Low road transfer, the easier of the two to facilitate, is achieved by maintaining a standard virtual environment. For further discussion of this concept, see: Perkins and Salomon.