Developing Weatherization Online Training Content (WxOT)

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ABSTRACT

The National Weatherization Training Portal (NWTP), currently under development, is a virtual campus offering online courses, manuals, videos and 3D interactive simulations of residential weatherization. The NWTP courses are presented in a flexible and adaptive learning platform that tracks each student's progress.

This paper describes a major project to develop Weatherization Online Training (WxOT) content and related resources for NWTP in order to expand its job education programs to online courses and electronic training aids, in hopes of training 65,000 weatherization workers in the next decade.

The content developed since 2010 includes 53 open source online training lessons. More than a third of the lessons use 3D, immersive, interactive learning environments. More than 20 percent of the lessons are educational game-based. Two game engines or frameworks are used – (1) a proprietary game engine (Vicious), and (2) an open source game-based interactive framework (IAF) powered by the NWTP / Kuda platforms and developed by JHT as a by-product of the WxOT project.

Lessons have been developed for three primary weatherization program audiences – installers, crew chiefs and auditors. Example lessons include such topics as insulating walls, air sealing of attics, basements and crawlspaces, weatherizing window and doors, blower door pressure testing.

All lessons developed have been reviewed and vetted by members of the national weatherization training centers.

This paper describes how you can access, use, and revise the resources produced by the project including underlying images, 3D models, videos, interactive game-based frameworks, and immersive test procedures. All lessons and resources are available on an open source basis. They may be freely modified and repackaged by users.

Introduction – Description of the Project

This presentation describes a major project to develop Weatherization Online Content WxOT) for NWTP. The content developed from 2010 through early 2012 includes some 53 open source online training lessons. More than a third of the online courses use advanced 3D, immersive, interactive learning environments.

Approximately 25 percent of the online courses are immersive educational games that are imbedded in a game-based engine. Two game engines or frameworks are used – (1) a proprietary game engine (Vicious) (see Figure 1), and (2) an open source game-based interactive framework

(IAF) powered by the NWTP / Kuda platforms and developed by JHT Inc. as a byproduct of the WxOT project.

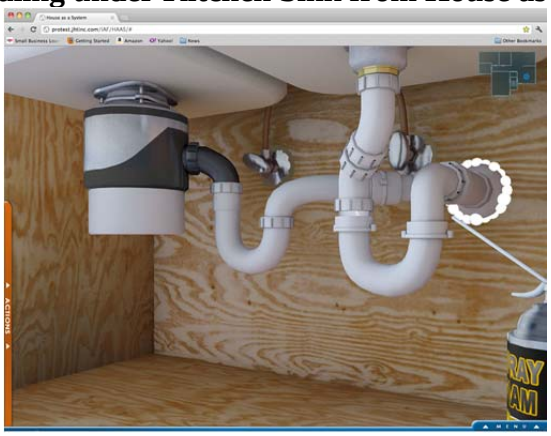
Figure 1. Avatar of Installer Air Sealing an Attic

Source: Lesson i- 6.1, Installer Course, www.weatherization.nterlearning.org

Figure 2. Living Room Scene from House as a System Part 2

Source: Game-based Lesson i- 3.6, Installer Course, www.weatherization.nterlearning.org

Figure 3. Air Sealing under Kitchen Sink from House as a System Part 2



Source: Game-based Lesson i- 3.6, Installer Course, www.weatherization.nterlearning.org

At the beginning of the WxOT project, only one game engine was available, and it was proprietary. The second game engine, the integrated architecture framework (IAF), was developed during the project to provide an open-source game-based platform within the NTER/Kuda environment. The refinement of the NTER/Kuda environment and the development of the IAF are major innovative products of the WxOT effort.

Two example screenshots are shown above in Figures 2 and 3 from the IAF game environment for the "House as a System" game-based lesson.

- The first screenshot in Figure 2 shows a partial list of possible actions shown in the tab at the left and the starting, current, and potential loads and energy scores shown at the lower right. The user's objective is to take actions to reduce loads and energy use during a northern US winter toward the "potential" while maintaining safety and health conditions and keeping within basic cost-effectiveness boundaries.
- The second screenshot in Figure 3 shows a still from an animation underway to seal leaks around the plumbing under the kitchen sink; this is one of over two-dozen animations included within this game-based lesson to demonstrate how the actions are to be performed. For this first phase of development of the IAF platform, avatars, or even just their hands and arms, have not been developed. It is expected that this would occur in future version of the platform.

Lessons have been developed for three primary weatherization program audiences – installers, crew chiefs, and auditors. Example learning lessons include such topics as insulating walls, air sealing of attics, basements and crawlspaces, weatherizing window and doors, blower door pressure testing.

All lessons developed have been reviewed and vetted by members of the national weatherization training centers.

This paper describes how you can access, use, and revise the resources produced by the project including underlying images, 3D models, videos, interactive game-based frameworks, and immersive test procedures. All lessons and resources are available on an open source basis. They may be freely modified and repackaged by users.

Mission and Intent

From the onset of the project at its June 21, 2010, kickoff meeting, the U.S. Department of Energy (DOE) Weatherization Online Training program was created to be:

> "*The development of a technology-enabled on-line training system using a blended learning approach and state-of-the-art and familiar social media to provide a modular, individualized, and customizable learning environment for the weatherization assistance program that is open source and replicable.*"

The goal of the project was to initiate development of online training in weatherization and then move into other areas within DOE's Energy Efficiency and Renewable Energy (EERE) program. Fueled by funds from the American Reinvestment and Recovery Act, DOE set its sights on training 65,000 weatherization professionals, and realized there was little possibility of reaching that goal using its traditional training methods.

Sharable Content Object Reference Model (SCORM)

The WxOT program was conceived to be a pilot education program using an open-source, SCORM-based, 3-D supportive learning platform (then called the National Weatherization Training Program (NWTP) and now known as National Training Education Resource (NTER), developed by SRI International for DOE's Office of Energy Efficiency and Renewable Energy. Over the two years of the project development, the WxOT program and the NTER platform grew up together, informing and encouraging each other's development.

From the larger perspective, DOE believes that the NTER platform, and the WxOT program as a showcase, will revolutionize the way professionals are trained in many different arenas, beyond weatherization projects and energy efficiency, to many disparate areas of learning. The potential outreach of the program includes, as a few examples, continuing education for to federal agencies, as well as training programs in building sciences for schools of architecture and engineering. (See ACEEE 2012 paper NTER, #1208.)

Audiences

From a more immediate perspective, the WxOT project aimed to create relevant training materials for new employees and people who wish to increase their skills in weatherization. It provides training lessons to develop the skill sets needed in three job positions. The WxOT project began on a solid foundation: the Department of Energy's Weatherization Assistance Program (WAP), established in 1978, already had developed a wealth of existing skillset definitions and learning objectives, as well as training materials on weatherization. The WxOT project was created by DOE to pinpoint the most relevant material and distribute it to the quickly growing numbers of users in a format through which they could learn quickly and easily.

The types of people whom the program seeks to train vary widely—from newly minted high school graduates to older unemployed workers seeking new job skills. This called for flexible learning vehicles in a variety of formats to appeal to a wide range of skills set and levels of comfort with electronic media. The project's "blended learning approach" combined a variety of lesson types, from 3D game-based lessons to "page-turner" PowerPoint –style lessons.

Approach

The project from its inception was intended to augment and enhance, rather than duplicate, the existing Weatherization Assistance Program curricula (see www.waptac.org). It also strove from the outset to provide learning material that could be "repurposed" by the state and local training centers as they see fit. As the project progressed, however, trainers in the state and local weatherization training programs expressed a desire to see the project's materials developed specifically for use in traditional classroom settings, as well as being directly accessible to the student learner. The project team restructured its development process and lesson content (in the form of SCOs—shareable content objects) to accommodate this request. The team began by classifying the SCOs under 5 training lessons:

- Introduction to the System and Developing Communication Skills
- House as a System
- Building Envelope

- Building Systems and Equipment
- Diagnostics

Although the naming and classifying of the SCOs changed numerous times, it is interesting to note that the 53 SCOs produced easily fall into the original five categories. Additional development concepts that the team need to consider from the outset included:

- Legacy material from the WAP program that eventually will need part of the program
- Mandatory credentialing for all weatherization workers may be on the horizon. DOE is looking for alternative forms of testing so that everyone who has the knowledge (including workers with 30 years of experience on the job with little formal education or those who use English as a second language) can pass the tests.
- Compliance with the 508 Section of the Disabilities Act, which requires that Federal agencies' electronic and information technology is accessible to people with disabilities.
- Mobile applications for field use also will be available from NWTP.
- Feedback, tests, knowledge checks, and review processes.

The Team

From its onset, the team was fortunate to be under the direction of Dr. Michelle Fox, the Chief Strategist for Education and Workforce Development for the Office of Energy Efficiency and Renewable Energy (EERE) within the Department of Energy, who employed her considerable extensive expertise in learning and training to conceive and direct the project. Alex Cohen, who added a high level of computer savvy and programming expertise to the mix, assisted her.

The multi-disciplinary NIBS team was assembled with four areas of expertise:

Management

- National Institute of Building Sciences –project management
- Institute for the Sustainable Performance of Building (SuPerB) –technical management, direction, and integration

Subject Matter Experts

- Steven Winter Associates (SWA) – content development
- Wiss, Janney, Elstner (WJE) – content development
- Building Media Inc. (BMI) – content development (BMI also served as media producer, and is listed a second time below in that capacity)

Instructional Systems Designers

- All About Training (AAT) – educational specialist
- NAVAIR – advanced distributed learning

Media Producers

- Building Media Inc. (BMI) – visual and video media development
- JHT Inc. (JHT) – simulation and animation media development, including
- Escape Hatch Entertainment (EHE) –gaming media development

The NIBS team had an incredible ally; SRI International worked in tandem with the NIBS Team throughout the course of the project. In the most stripped-down project description, the NIBS Team was to do the course development and training, while SRI Team continued in parallel with the platform development.

As with all plans, this one began permutating early in the process. The permutations allowed the teams to learn from and help each other, resulting in synergistically superior products from both. An early example of the high level of cooperation that prevailed throughout the project was the Stanford, Ca. –based "Code-a-thon," a two-day training program hosted by SRI for the NIBS team media developers to learn about programming in the ontology-based platform's O3D environment. Energy Enterprise Solutions (EES) provided oversight for SRI's platform development.

Midway through the project, as the need for more "hand-on" expertise became apparent, the team expanded to include field experts through the more direct involvement of Montana State University's WxTV personnel and WAP Center trainers under the direction of Simonson Management Services, a contractor to the WAP program.

Open communications was the key to keeping this project on track. In addition to meeting as a whole team, the project members formed ad-hoc groups, on an as-needed basis, in three types:

- Topics Groups to define specific issues, such as copyright issues, the look and feel of the presentations, and a style guide
- Task Groups that coordinated by job function, such as the Media Producers Group
- SCO Groups that formed for the development of individual SCOs and comprised of a SME, a media producer, and an instructional designer

SuPerB also called in specialists on an as-needed basis, including Jon Scoresby, PhD, an instructional designer with educational game expertise, and Laura Strong of Studio Strong, a web interface designer.

The composition of the team members could vary considerably by lesson. Because of this, each of the 53 lessons produced by the project contains a table at the end that lists the specific roles of the team members who had key roles in producing that lesson. Also, a complete listing of project team meeting participants will be listed at: www.weatherization.nterlearning.org.

Development Process and the Rainbow Schedule

The project schedule was extremely tight, given the time limit on using the economic stimulus money. Thus, it was important to track the development of the 50+ SOCs, or lessons, and to remove barriers to the speedy production of high quality products.

Most lessons (SCOs) underwent the same development process and sequence as follows: (1) Outline, (2) Storyboard, (3) Draft authoring in NWTP, (4) Develop Media, (5) Alpha Authoring in NWTP, (6) Finish Alpha of working SCO, (7) conduct QA, (8) SMS reviews of Alpha, (9) Revise SCO, (10) do final QA and review, (11) publish on NTER's NWTP Public Site.

The Institute for the Sustainable Performance of Buildings (SuPerB), the technical director for the project, maintained a detailed online schedule of the development status of all lessons (SCOs) through the phases just listed. The schedule was color-coded, and was available to all team members.

One project object was to demonstrate emerging interactive 3D browser-based interactivity, especially game-based learning. Unfortunately, the software platforms for this were under development. SRI was actively developing NTER and Kuda. NTER has undergone continuing development during the course of the project. Kuda has gone from Version 1, to 1.5, to version 2.0 during the course of the project, via a number of releases. The project team has been using the latest version of these tools as they became available. As a result, some of the most immersive, game-based SCOs that best demonstrate the capabilities of the emerging browser-based 3D technology are just under development at the very end of the project, now that the tools have been developed and refined. Example game-based lessons using emerging capabilities include:

- Lesson i- 3.3 Driving Forces & Airflow
- Lesson i- 3.6 House as a System - Part 2
- Lesson a- 9.6 Duct-Induced Room Pressure Imbalance

See www.weatherization.nterlearning.org.

WxOT Project Has Produced Key Innovations for Online Learning

The project has produced some very innovative capabilities and features. All are open source, and some are already being used in other projects and software platforms.

Game-Based Interactive Framework

Media producer JHT, Inc. has done really good work in learning how to produce first-rate media products using the emerging Kuda platform along with the emerging WebGL browser capabilities and within the Ilius learning management system. Once they had mastered the basics, they set themselves the task of developing a set of JavaScript functions that would produce a game-like environment, an interactive framework (IAF). Three game-based lessons in the WxOT project are under development using this new IAF framework.

Also, two other DOE projects are using the IAF framework. One project is developing seven lessons to provide photovoltaic online training (PVOT) for code officials inspecting photovoltaic installations for code compliance. Another project is developing an eLearning platform for use with problem-based scenarios in providing training about lighting and daylighting (eLAD) in office buildings. Products from both projects will be available on the NTER platform once completed during the summer of 2012.

Interactive Chapter-Level Assessment (or Testing)

A really innovative approach to chapter-level testing was conceived and developed by one of the instructional designers on the project, Clayton McNatt of NAVAIR. He developed an immersive and interactive approach to conducting assessments at the chapter level. JHT provided strong media support. A student can take a test, and respond to 3D test situations by taking an action. The system interprets and scores the action taken. The student does not need to "answer" a "question." This new capability is highly innovative. The name of this lesson is "i- 7.0t Blower Door Basics Chapter Assessment." SRI needed to develop some special reporting routines to allow this new feature to properly report test results within the LMS system. Those special reporting routines were developed in the spring of 2012.

WxOT Products

The project has produced 53 SCOs, or lessons. A summary is presented in the tables on the following two pages. Their main characteristics break down as follows:

Primary Audiences

- WAP Installer: 24 lessons
- WAP crew chief: 7 lessons
- WAP auditor: 22 lessons

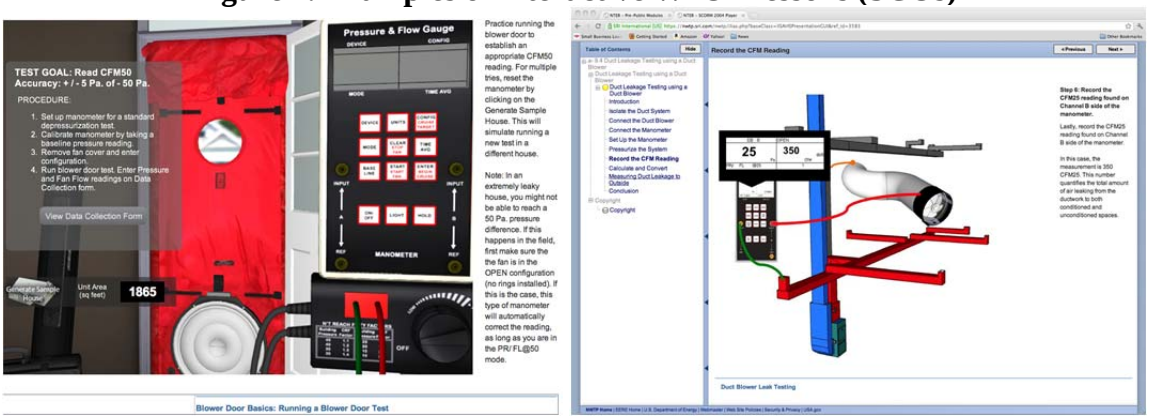
The WAP instructors are the secondary audience for most of the lessons.

Types of Presentations

Page-turners. 25 lessons are traditional sequential online lessons with photos and possibly videos, but with little interactivity or immersion.

Interactive. 7 lessons are Interactive; these are like page-turners, but also contain traditional interactivity with 2D and 3D media.

Figure 4. Examples of interactive WxOT lessons (SCOs)

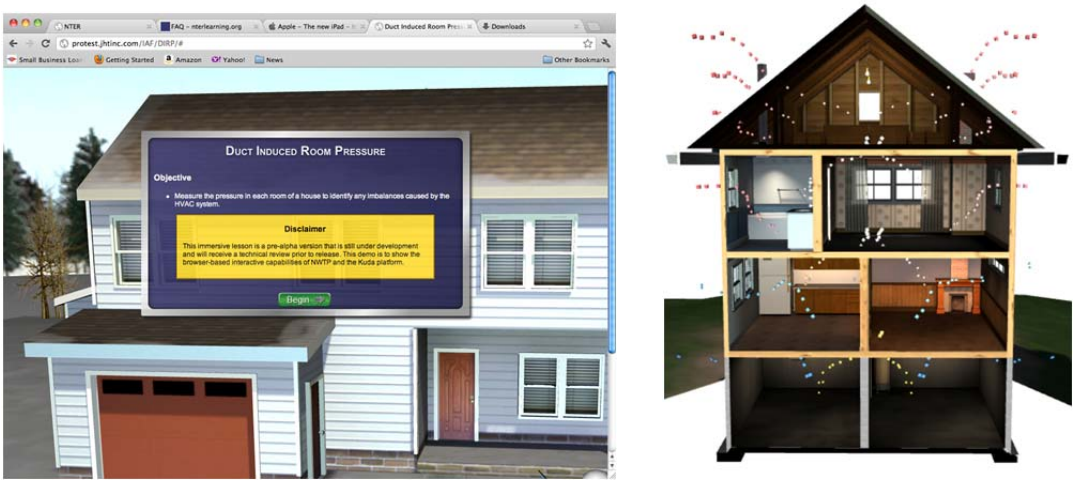


Source: selected screens from Auditor's Course, www.weatherization.nterlearning.org

Immersive. 20 lessons are Immersive. These are like interactive lessons, but the user has more control over the flow and sequence of the learning experience. In practice, these 20 lessons vary widely in the degree of immersion.

Game-based. 12 SCOs are Game-Based. These are immersive lessons with increased learning potential of gaming features – problem based goals or challenges, scoring. Nine of these game-based lessons use the proprietary Vicious game engine, while three lessons use the new open source Kuda-based IAF interactive framework.

Figure 5. Examples of game-based WxOT lessons (SCOs)



Source: selected screens from Installer's Course, www.weatherization.nterlearning.org

How to Access and Use the WxOT Products

To Access and Use the WxOT Lessons

To access and use the 53 lessons developed by this project, go to: www.weatherization.nterlearning.org

Follow the instructions on this site. Several web pages have been developed and will be deployed to assist you in navigating this site. Tutorials are also available.

At the present time, in the spring of 2012, we suggest you use the latest version of the Chrome browser.

To Download WxOT Resources to Use and Revise

To access the source code for any lesson, or photos, videos, or other 2D or 3D media, go to the web page on WxOT Resources under the main www.weatherization.nterlearning.org page. This page has been designed and will be deployed in the late spring or early summer of 2012. The page will provide detailed instructions for how to download all WxOT resources, plus general guidance on how to use the materials thus downloaded.

Table 1. Listing of WxOT Lessons (SCOs) Produced (Part 1 of 2)

WAP Chapter Topic	SCO (Lesson) Nbr.	SCO (Lesson) Name	WAP Audiences: Primary / Secondary	Approach	Platform
Fundamentals	i- 3.1	Basics & modes of Heat Transfer	Installer / Instructor	Interactive	NWTP-Kuda
Fundamentals	i- 3.2	Moisture	Installer / Instructor	Interactive	NWTP-Kuda
Fundamentals	i- 3.3	Driving Forces, Airflow, & Stack Effect	Installer / Instructor	Immersive	NWTP-Kuda-Game
Fundamentals	i- 3.4	Building Envelope Thermal & Pressure Boundaries	Installer / Instructor	Interactive	NWTP-Kuda
Fundamentals	i- 3.5	House as a System - Part 1	Installer / Instructor	Interactive	NWTP-Kuda
Fundamentals	i- 3.6	House as a System - Part 2	Installer / Instructor	Immersive	NWTP-Kuda-Game
Fundamentals	i- 3.7	Building Variations (animated glossary)	Installer / Instructor	Animated Glossary	Sketchup
Insulation	i- 5.1	Insulation Options & Safety	Installer / Instructor	Page Turner	NWTP
Insulation	i- 5.2	Introduction to Insulation Blowing Equipment	Installer / Instructor	Page Turner	NWTP
Insulation	i- 5.3	Insulating Attics	Installer / Instructor	Page Turner	NWTP
Insulation	i- 5.4	Insulating Walls	Installer / Instructor	Immersive	Vicious-Game
Insulation	i- 5.5	Insulating Crawlspaces & Basements	Installer / Instructor	Page Turner	NWTP
Air Sealing	i- 6.1	Air Sealing Attics (Finding & Fixing)	Installer / Instructor	Immersive	Vicious-Game
Air Sealing	i- 6.2	Air Sealing Basements & Crawlspaces	Installer / Instructor	Page Turner	NWTP
Air Sealing	i- 6.3	Air Sealing for separation: Garage, Porches, between occupancies	Installer / Instructor	Page Turner	NWTP
Air Sealing	i- 6.4	Weatherizing Windows & Doors	Installer / Instructor	Page Turner	NWTP
Blower Door	i- 7.0t	Blower Door Basics Interactive Test	Installer / Instructor	Immersive	NWTP-Kuda
Blower Door	i- 7.1.1	Setting Up a Blower Door Part 1	Installer / Instructor	Immersive	NWTP-Kuda
Blower Door	i- 7.1.2	Setting Up a Blower Door Part 2	Installer / Instructor	Immersive	NWTP-Kuda
Blower Door	i- 7.1.3	Setting Up a Blower Door Part 3	Installer / Instructor	Immersive	NWTP-Kuda
Blower Door	i- 7.2	Preparing for a Blower Door Test	Installer / Instructor	Immersive	NWTP-Kuda
Blower Door	i- 7.3	Blower Door Test Procedures	Installer / Instructor	Immersive	NWTP-Kuda
Blower Door	i- 7.4	Interpreting Blower Door Test Results	Installer / Instructor	Immersive	NWTP-Kuda
Blower Door	i- 7.5	Blower Door Guided Air Sealing	Installer / Instructor	Page Turner	NWTP

Source: www.weatherization.nterlearning.org.

Table 1. Listing of WxOT Lessons (SCOs) Produced (Part 2 of 2)

WAP Chapter Topic	SCO Nbr.	SCO (Lesson) Name	WAP Audiences: Primary / Secondary	Approach	Platform
Combustion Safety	c- 4.1	CAZ testing	Crew Chief / Instructor	Immersive	Vicious-Game
Combustion Safety	c- 4.2	Combustion Safety Testing: Water heater & Furnace / Boiler	Crew Chief / Instructor	Immersive	Vicious-Game
Insulation	c- 5.1	Understanding Effective R-value	Crew Chief / Instructor	Page Turner	NWTP
Equipment	c- 10.1	Identifying Heating Equipment	Crew Chief / Instructor	Page Turner	NWTP
Equipment	c- 10.2	Identifying Hot Water Systems	Crew Chief / Instructor	Page Turner	NWTP
Equipment	c- 10.3	Identifying Combustion Exhaust	Crew Chief / Instructor	Page Turner	NWTP
Equipment	c- 10.4	Identifying Cooling Equipment	Crew Chief / Instructor	Page Turner	NWTP
Assessment	a- 2.0	Visual Assessment	Auditor	Page Turner	NWTP
Assessment	a- 2.1	Exterior Walk around	Auditor	Page Turner	NWTP
Assessment	a- 2.2	Interior Walk around	Auditor	Page Turner	NWTP
Assessment	a- 2.3	Attic Assessment	Auditor	Page Turner	NWTP
Assessment	a- 2.4	Basement/Crawlspace Assessment	Auditor	Page Turner	NWTP
Assessment	a- 2.5	Furnace Inspection (was HVAC Inspection)	Auditor	Page Turner	NWTP
Assessment	a- 2.6	Water Heater Inspection	Auditor	Page Turner	NWTP
Assessment	a- 2.7	Building Measurements	Auditor	Immersive	Kuda
Assessment	a- 2.8	Gas Leak Detection	Auditor	Page Turner	NWTP
Combustion Safety	a- 4.1	Combustion Safety Testing: Gas range/oven	Auditor	Immersive	Vicious-Game
Insulation	a- 5.1	Evaluating Attic Insulation	Auditor	Interactive	NWTP-Kuda
Blower Door	a- 7.1	Target Air-Leakage Reductions	Auditor	Page Turner	NWTP
Blower Door	a- 7.2	Room Pressure Tests, thermal boundary, & Add-a-hole (ZPD Case Study)	Auditor	Page Turner	NWTP
Ventilation	a- 8.1	Building Airflow Standards (Intro to MVL, BTL, BAS)	Auditor	Page Turner	NWTP
Ventilation	a- 8.2	ASHRAE 62.2	Auditor	Interactive	NWTP-Kuda
Ventilation	a- 8.3	Mechanical Ventilation	Auditor	Page Turner	NWTP
Ductwork	a- 9.1	Measuring Duct Leakage with a Blower Door	Auditor	Immersive	Vicious-Game
Ductwork	a- 9.2	Pressure Pan Testing	Auditor	Immersive	Vicious-Game
Ductwork	a- 9.3	Dominant Duct Leakage	Auditor	Immersive	Vicious-Game
Ductwork	a- 9.4	Duct-Blower Leak Testing	Auditor	Page Turner	NWTP
Ductwork	a- 9.5	Duct Induced Room Pressure Imbalance	Auditor	Immersive	Vicious-Game
Ductwork	a- 9.6	Duct Induced Room Pressure Imbalance	Auditor	Immersive	NWTP-Kuda-Game

Source: www.weatherization.nterlearning.org.

Conclusions

The National Weatherization Training Portal (NWTP) is a virtual campus offering online courses, manuals, videos and 3D interactive simulations of residential weatherization. The NWTP courses cover basic and advanced building science and weatherization through a flexible and adaptive learning platform that tracks each student's progress.

This paper has described this major project to develop Weatherization Online Training (WxOT) content and related resources for NWTP in order to expand its job education programs to online courses and electronic training aids, in hopes of training 65,000 weatherization workers in the next decade.

The content developed from 2010 through early 2012 includes 53 open source online training lessons. More than a third of the online courses use advanced 3D, immersive, interactive learning environments. More than 20 percent of the online courses are immersive educational games that are imbedded in a game-based engine. Two game engines or frameworks are used – (1) a proprietary game engine (Vicious), and (2) an open source game-based interactive framework (IAF) powered by the NWTP / Kuda platforms and developed by JHT as a by-product of the WxOT project.

Lessons have been developed for three primary weatherization program audiences – installers, crew chiefs and auditors. All lessons developed have been reviewed and vetted by members of the national weatherization training centers.

The 53 lessons produced are an important online contribution to the content available to the weatherization community and others. The combination of the NTER platform coupled with the WxOT source code and media resources are thought by several key participants in the WxOT process to provide an even stronger contribution to the community.

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