WEB-BASED SUPPLEMENTAL TRAINING IN CONTINUING ENGINEERING EDUCATION COURSES

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A continuing engineering education course on process burners used in the hydrocarbon and petrochemical industries contained some basic theory that proved to be a concern for many of the students. Recent graduates felt too much time was spent on it, while those who graduated some time ago wanted more time spent on it. Instructors felt rushed trying to cover all of the required material for the course. An online course consisting of a series of short web-based modules was developed to address these concerns. This allows students to proceed at their own pace, while freeing up classroom time for instructors. The asynchronous course is completed by the students prior to attending the face-to-face class.

Introduction

Continuing professional education is critical for graduate engineers because of rapid changes in technology (NRC, 1985; NAE, 2005). However, as noted by Biedenbach (1978), continuing education is not typically very high on the priority list for employed engineers, so the training must be convenient and relevant. This education may take a variety of forms ranging from 30 minute webinars to advanced graduate degree programs. This paper focuses on technology-specific short courses that last two days, eight hours per day. One challenge for continuing professional development courses is the diversity of students' education and experience. Some may be recent graduates who are well versed in the basics, but have little or no practical experience. Others may have graduated some time ago and have lots of practical experience, but may not remember some of the basics they learned in school.

The John Zink Institute (JZI) has been providing face-to-face (F2F) technical training to engineers in the hydrocarbon and petrochemical industries for nearly 20 years. Students come to JZI to be taught by a team of highly qualified and experienced instructors on technologies such as process burners and flares. An important element of the training is live demonstrations in a world-class test facility. While abbreviated versions of these classes have been delivered at plant sites, there are some important limitations. Demonstrations are very difficult in an actual operating plant, which does not have the flexibility of rapidly changing conditions to demonstrate various principles. Plants do not typically have the variety of equipment that can be demonstrated in a manufacturers' test facility (see Figure 1). It is also generally impractical to send a full team of up to a dozen instructors to a plant site.

Figure 1. John Zink R&D Test Center in Tulsa, OK (USA).

The particular continuing engineering education course under consideration here is called Process Burner Fundamentals (PBF), which is course number PB107. A typical class is shown in Figure 2. In these F2F classes, the first half day had typically been spent covering some basic topics, including combustion fundamentals, heat transfer, and fluid flow. While entire semesters and more are often spent on these topics in the university, only about an hour was spent on each in PB107. However, these basics are important to ensure that students are familiar with the terminology and principles that will be covered later in the more advanced topics, such as process burner fundamentals and heater operations. The basic topics are also approached from the perspective of how they apply to process burners and heaters. For example, one-dimensional steady-state conduction through a composite refractory wall in a heater is the only topic covered for thermal conduction heat transfer (see Figure 3). Since natural convection heat transfer is not usually important in process heaters, it is not covered at all. Each student receives a copy of *The John Zink Combustion Handbook* (Baukal, 2001), which contains much more detailed developments of the topics covered in class. Videos, a process simulator, live demonstrations, and interaction between students and instructors are critical elements in the F2F class which can not be easily duplicated online.

JZI is accredited by the International Association for Continuing Education and Training (IACET). The PBF course is also accredited by the American Petroleum Institute (API). One of the IACET accreditation requirements is some measure of student learning, usually in the form of a pre-test and post-test. JZI uses identical pre- and post-tests so learning can be approximated by the difference between the scores. The need for PB107 is demonstrated by an average pre-test score for hundreds of students in the range of 25%. Post-test scores are generally above 90%. While burners have been used in process heaters for decades, rapid technological changes have occurred in the past decade to meet more stringent pollution regulations, further emphasizing the importance of training even for experienced engineers.

Figure 2. Photo of a typical short course class.

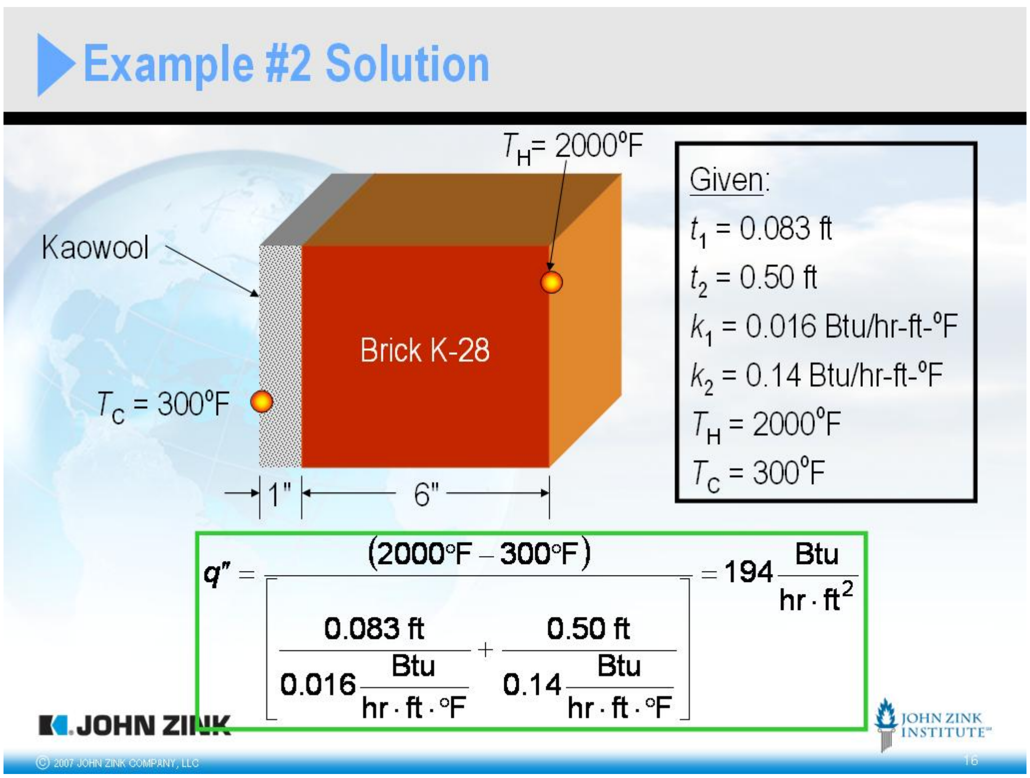

Figure 3. Example of thermal conduction through a heater wall.

Web-Based Course Development Requirements

One of the requirements for both IACET and API is that students must complete an evaluation at the completion of each class. The evaluation form asks students to comment on the material in each section of the course. Student critiques of the three basic topics in past courses have ranged from “spent too much time on them” to “went too fast on them.” Students have also wanted to spend more time on some of the other more advanced topics. Instructors have often had difficulty covering all of the required materials in the available time.

To address these problems, a series of online modules was developed to be completed by the students prior to coming to the classroom. There were several important requirements for the online training. The first was that it had to be asynchronous. While the F2F class would be held at the same time for all students, there is no fixed registration period so students needed to be able to start the online course at any time. Students come to JZI from all over the world and are in multiple time zones, which makes synchronous online training difficult. Whelan (1997) notes that online courses may not be appropriate for all types of courses, but may be a preferred alternative for certain niche applications which is the case here.

Another important requirement was that each module had to be relatively short and somewhat independent of other modules. This was because of plant engineers' work schedules that often do not permit long lengths of uninterrupted time while in the plant, particularly if the plant is in a turnaround which requires very long work days and few days off. Engineers need to be able to complete the modules at their own pace, which may be somewhat erratic depending on what is happening in the plant at a particular point in time. Ibieta (1998) notes the importance of lifelong training that can be done without interfering with work demands, which is often why asynchronous learning is preferred. The modules could not be too video-intensive because fast computers are not always readily available, particularly in certain parts of the world. The final requirement was documentation of completion, in the form of a brief quiz, for each module.

An important requirement for JZI was that the implementation could not take an inordinate amount of time, require specialized programming knowledge, or be cost prohibitive. The software should preferably be able to use Powerpoint slides, most of which were already substantially developed, and not have a steep learning curve. JZI is only a small part of an industrial equipment manufacturer, without course developers and education programmers that are typically available at universities and other large education institutions. For example, Uskov (2003) describes a third generation web-based instructional tool with sophisticated capabilities that are beyond the practical scope for smaller industrial-based lifelong learning programs.

Web-Based Course Development

A new online course entitled Process Burner Theory (PBT), which is course number PB155, was developed that includes three series of modules. Each series has 5 or 6 modules on combustion fundamentals, fluid flow, and heat transfer as follows:

Series	Module Title	Module Number
Combustion Fundamentals	Combustion Terminology	CO146-1.0
Combustion Fundamentals	Fuels	CO146-2.0
Combustion Fundamentals	Combustion Safety	CO146-3.0
Combustion Fundamentals	Meter the Fuel and Air	CO146-3.1
Combustion Fundamentals	Mix the Fuel and Air	CO146-3.2
Combustion Fundamentals	Maintain Ignition	CO146-3.3
Fluid Flow	Introduction to Fluid Flow	CO147-1.0
Fluid Flow	Irregular Flame Patterns	CO147-2.0
Fluid Flow	Defining Furnace Draft	CO147-3.1
Fluid Flow	Measuring and Controlling Draft	CO147-3.2
Fluid Flow	Flow Through Nozzles	CO147-4.0
Heat Transfer	Heat Transfer Mechanisms	CO148-1.0
Heat Transfer	Conduction	CO148-1.1
Heat Transfer	Convection	CO148-1.2
Heat Transfer	Radiation	CO148-1.3
Heat Transfer	Heat Transfer in Furnaces	CO148.2.0

Each of the 16 modules is designed to be completed in approximately 10-15 minutes where students can go as fast or as slow as they want. The short module length is designed specifically for engineers working in plants who often do not have time to complete lengthy online courses during the typical working day. While the modules are related, they are independent enough that they can be completed over a period of time and even out of order without a significant loss of continuity. This allows engineers to complete the modules at their own pace anywhere with internet access. The modular format makes it easy to re-use the modules in other future courses.

The modules were developed using a software package called Articulate (www.articulate.com). Audio was added to the Powerpoint slides originally developed for the classroom using Articulate. A script (see the upper right block shown in Figure 4) was developed for each slide to make it easier for the narrator. Notations (e.g., "click1") were made in the script as appropriate for slides with animations.

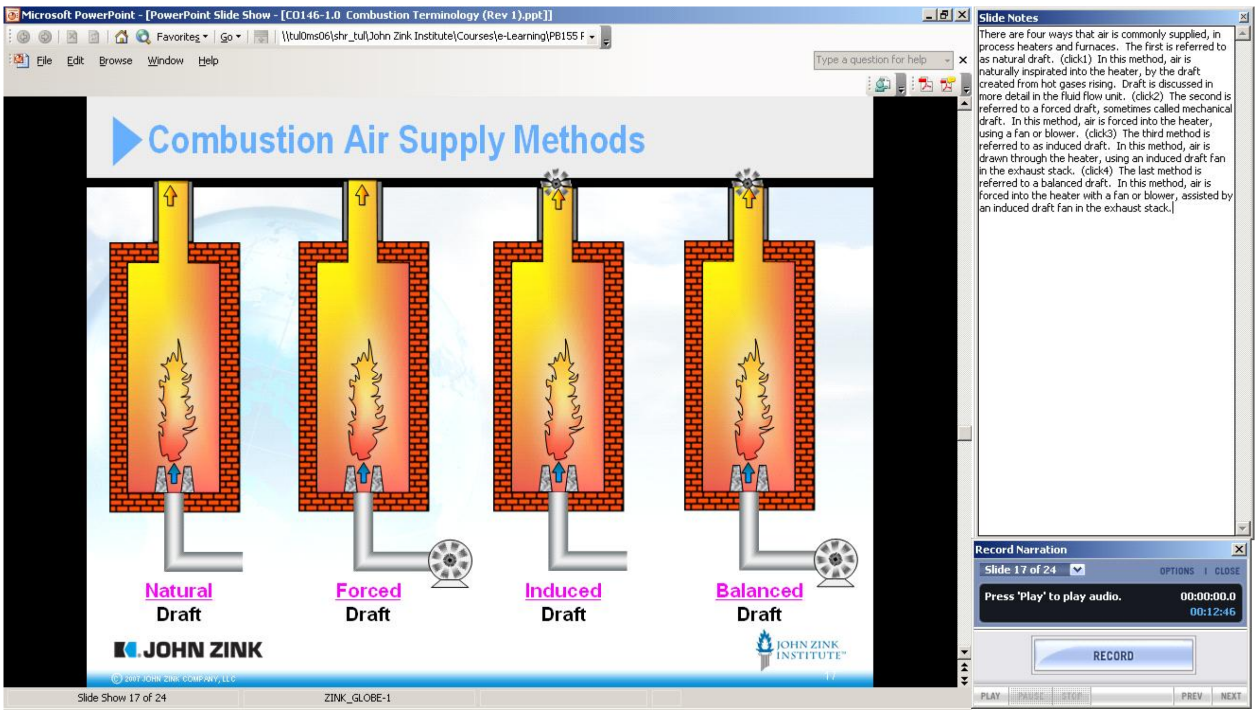

Figure 4. Example of an Articulate screen.

Each module contains a five question quiz used to indicate satisfactory course completion where a minimum of four questions have to be answered correctly. The quizzes were developed using a software package called Quizmaker, which is an available option with Articulate. A sample Quizmaker development screen is shown in Figure 5. The example shown is for a multiple response question where multiple answers are possible. Many other types of questions are available such as True-False, multiple choice (a single correct answer), matching, and fill-in-the-blank. The test is designed so that students must complete it once they start it. Failure to pass the test means they have to start the module again, although they can go directly back to the quiz if they so choose. Test questions are straightforward and relatively simple after completing the module, but are not so simple they can easily be answered with no prior knowledge. The quiz answers are randomized. It is also possible to randomize the questions and to select questions from a larger pool, although these options were not used in this case.

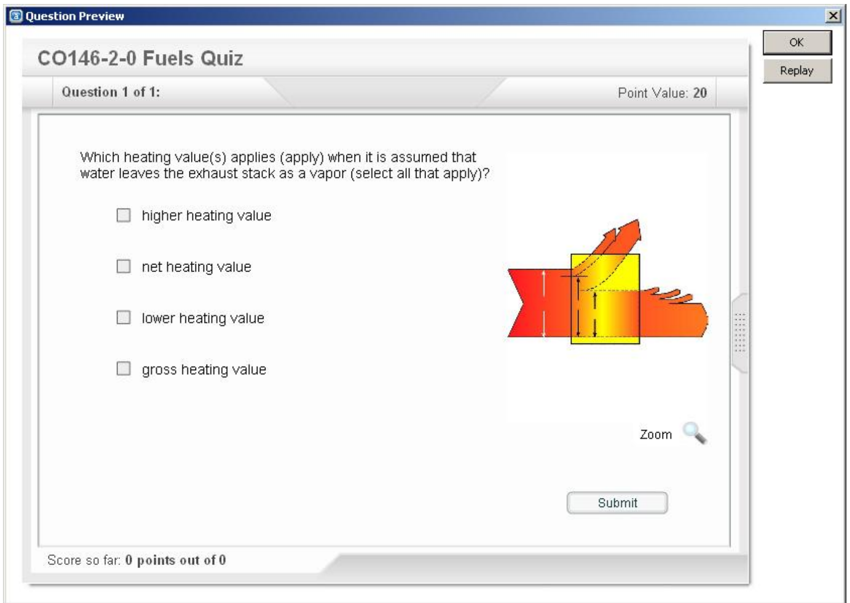

Figure 5. Example of a Quizmaker screen.

Figure 6 shows an example screen from a completed module entitled “Irregular Flame Patterns.” The block on the left shows an outline of the slides in the module, where the slide shown is number 12 out of at total of 22. The audio in this particular slide takes 51 seconds to complete, where the slide progress is shown on the blue bar at the bottom center. At the completion of this slide, the student is done 4:57 (4 minutes and 57 seconds) out of 10:09 (see top of frame next to course title), not including the time to complete the quiz. The student can use the outline at the left to go to any slide, in addition to using the controls at the bottom to replay the slide or advance to the next slide as desired. The header block at the top left contains buttons to show the instructor’s bio or to send an email to the instructor. To date, none of the 138 students who have completed the online course has sent an email to the instructor. Students have contacted the registrar for help on getting access to the Learning Management System used to administer the course.

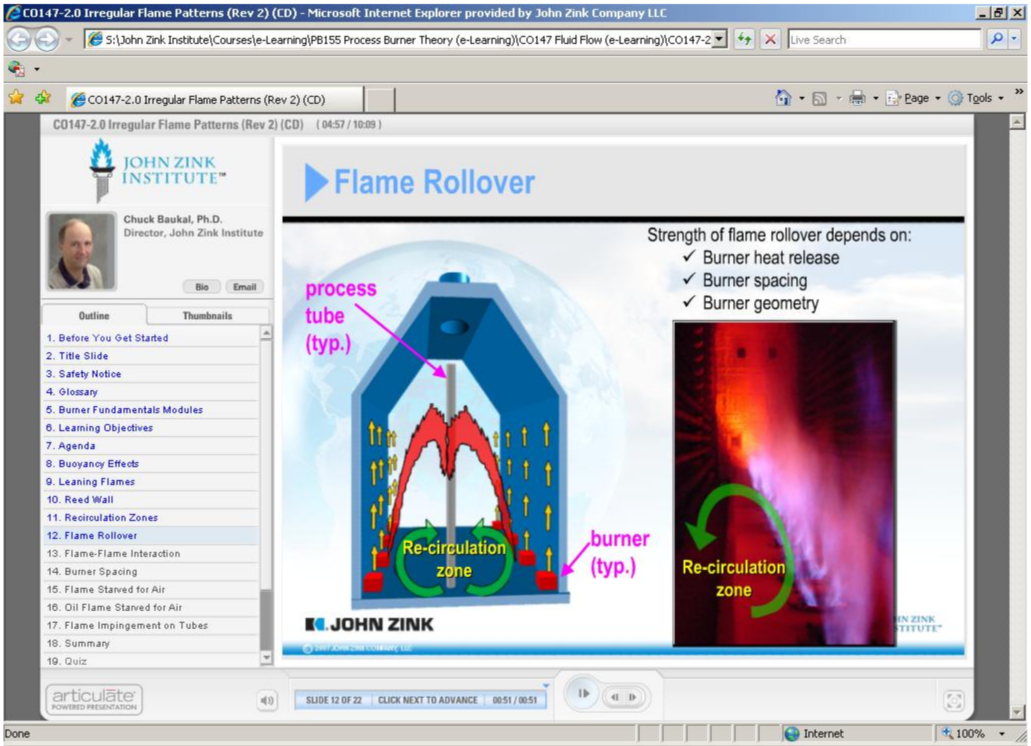

Figure 6. Example of a screen from a completed module.

Implementation

Students are required to complete the online course PBT prior to coming to the F2F PBF. PBT course progress is monitored by the registrar in the weeks leading up to PBF. Reminder notices are sent out periodically about course progress.

At the beginning of the F2F class, the online module topics are reviewed in a one hour session and supplemented with some hands-on activities and simulations, before moving on to the specific topic areas. One of the hands-on activities used to review the online materials involves a candle. Each student lights their own candle and makes observations about the flame. Suggestions are given for some things to look for that involve combustion fundamentals, fluid flow, and heat transfer. For example, the candle flame involves laminar flow and has both convective and radiative heat transfer. A simulator (see Figure 7) is used to demonstrate some of the principles studied in PBT, such as setting the draft in a process heater.

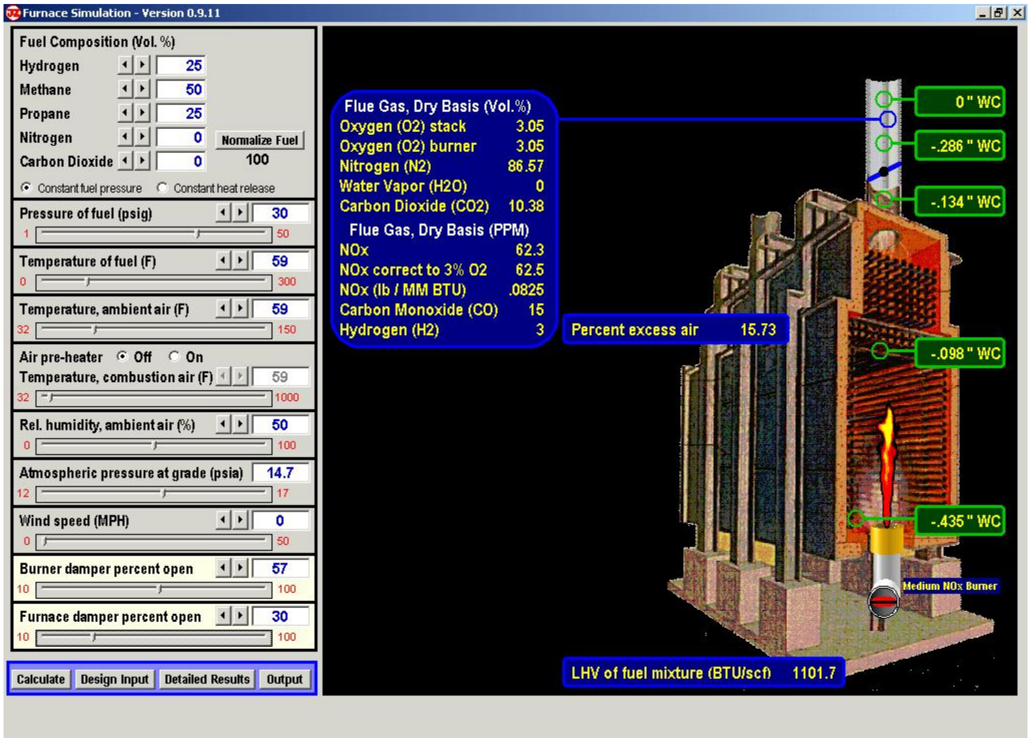

Figure 7. Example screen from heater simulator.

The use of distance learning as a course prerequisite has also freed up time in the classroom to spend more time on some technology-specific topics. Additional time is spent on some of the other topics and one new topic, burner specifications, has been added to the F2F course curriculum.

Conclusions

The online training course described here was first offered in 2007. To date, two sets of students have completed the training with 59 in the first set and 79 in the second set. Although it was not originally designed to be a stand-alone course, 16% of the online students have not taken the F2F class for a variety of reasons, mostly related to logistics and the difficulty in going to Tulsa at the scheduled course times. The online course solved two major concerns related to the F2F course: the amount of time spent on some basic theory and the instructors' difficulty in adequately covering the course content in the allotted time. The online course allows students to go at their own pace, including reviewing materials if desired. It also freed up time in the course to better cover more advanced topics and to add a new topic to the curriculum.

References

Baukal, C.E. (2001). *The John Zink Combustion Handbook*. Boca Raton, FL: CRC Press.

Biedenbach, J.M. (1978). Media-Based Continuing Engineering Education. *Proc. of IEEE*, **66** (8), 961-968.

Ibieta, R. (1998). Lifelong Learning and the Virtual Campus – A Proposal for Asynchronous Learning. *Frontiers in Education Conf.*, **3**, Tempe, AZ, November 4-7, 1262-1266.

National Academy of Engineering, *Educating the Engineer of 2020*, Washington, DC: National Academy Press, 2005.

National Research Council (1985). *Engineering Education and Practice in the United States: Continuing Education of Engineers*, Washington, DC: National Academy Press.

Uskov, V. (2003). A 3rd generation web-based instructional tool for education and lifelong learning. *Int. J. Cont. Engineering Education and Lifelong Learning*, **13** (1/2), 110-131.

Whelan, P.F. (1997). Remote access to continuing engineering education (RACeE). *Eng. Sci. & Educ. J.*, **6** (5), 205-211.

Curriculum Vitae

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