

NDT Training in the Virtual World

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Abstract

Advanced ultrasonic testing is now a widely accepted and frequently mandated method of inspection. It can either enhance existing ultrasonic capability, or more often in lieu of radiography for particular applications. Phased Array (PAUT) and Time of Flight Diffraction (ToFD) are complex methodologies; with no shortcut solution to ensuring its competent use. Upskilling from conventional an ultrasonic operator, to fully a certified advanced ultrasonic technician in accordance with EN ISO 9712, requires over 100 hours training and 6 months industrial experience. There is now an innovative alternative to the training aspect, ‘Blended Learning’; a mix of e-learning, and in-class practical training with a subsequent competence assessment or full certification. E-learning is an established and accepted method of academic and vocational training for many professions; it provides an opportunity to access training which would otherwise be cost and time prohibitive. It permits students to study the complex theory at their own pace; whilst also appealing to differing learning styles. Visual Learners learn best by watching a demonstration or reading an explanation, Auditory Learners by listening to an explanation and repeating it out loud, and Kinesthetic Learners through hands-on experience; the blended learning approach caters for each of these and more.

1. Introduction

Online training is used in many industries to train and update the training of employees. Usually the knowledge being taught is of theoretical nature and rarely has a physical application. In the case of online training for phased array ultrasonic testing (PAUT), the goal is to train technicians on the theory of PAUT and on how to physically do they work. This present some specific challenges because of the amount and complexity of

the theory underlying PAUT and the hands-on nature of the work. In this paper, we review some of these challenges and provide solutions to them.

2. Challenge: Complexity of PAUT theory

For all the advantages it brings, the theory behind phased array ultrasonic testing is more complicated than the theory behind conventional ultrasonic testing. Concepts of electronic beam steering and focusing must be explained as well as the implications of the complex shape of the beam. New views such as the S-Scan and L-Scan must be explained and data analysis reviewed as it is fundamentally different especially when recorded data is involved.

Since there is no teacher to answer questions or sort out the confusions, this theory must be presented in a very clear and ordered way that will lead the student step-by-step in his learning process.

2.1. Solution: Organized and recurrent structure

Particular care should be taken when conceiving the structure of the training. The order in which each topic is introduced is extremely important. A poorly plan structure can create confusion and misconceptions. A recurrent structure is a good tool to guide students through the learning of complicated material. It creates a familiar environment, helps students learn key concepts step-by-step and, through series of interactive exercises, helps students develop a good workflow. For example, the training can be divided in five main sections. Each section contains a recurrent structure:

Table 1. Recurrent structure of the sections

Ultrasound	Phasing	Steering	Focusing	Data Quality
History	History	History	History	History
Hardware	Hardware	Hardware	Hardware	Hardware
Views & Scans	Views & Scans	Views & Scans	Views & Scans	Views & Scans
Theory	Theory	Theory	Theory	Theory
Procedures	Procedures	Procedures	Procedures	Procedures
Setups	Setups	Setups	Setups	Setups
Calibration	Calibration	Calibration	Calibration	Calibration
Inspection	Inspection	Inspection	Inspection	Inspection
Data Analysis	Data Analysis	Data Analysis	Data Analysis	Data Analysis
Interactive Exercises	Interactive Exercises	Interactive Exercises	Interactive Exercises	Interactive Exercises
Self-evaluation Test	Self-evaluation Test	Self-evaluation Test	Self-evaluation Test	Self-evaluation Test

Each series of interactive exercises contains a recurrent structure:

Table 2. Recurrent structure of the interactive exercises

Series 1	Series 2	Series 3	Series 4	Series 5	Series 6
Setup	Setup	Setup	Setup	Setup	Setup
Velocity Cal.	Velocity Cal.	Velocity Cal.	Velocity Cal.	Velocity Cal.	Velocity Cal.
Wedge Delay Cal.	Wedge Delay Cal.	Wedge Delay Cal.	Wedge Delay Cal.	Wedge Delay Cal.	Wedge Delay Cal.
TCG Cal.	TCG Cal.	TCG Cal.	TCG Cal.	TCG Cal.	TCG Cal.
Encoder Cal.	Encoder Cal.	Encoder Cal.	Encoder Cal.	Encoder Cal.	Encoder Cal.
Scanning	Scanning	Scanning	Scanning	Scanning	Scanning
Data Analysis	Data Analysis	Data Analysis	Data Analysis	Data Analysis	Data Analysis

2.2. Solution: Separating the theory from the instrument

To avoid confusion between theory induced problems, for example the splitting of a focused beam, and instrument induced problems, for example the wrong focal laws being calculated, the theory should be explained in a neutral environment. In other words, the reason behind calibration should be explained separately from the process of calibrating on a given instrument. This method gives students an understanding of what is calibration and how to do a calibration.

3. Challenge: Quantity of information

A student's capacity to assimilate knowledge on any given day is dependent on several variables, many of which are beyond the student's control. Hence, depending on the day of the week, the period of the day, the amount of rest acquired the previous night or even the food he has eaten, a student has a variable capacity to efficiently assimilate knowledge. In a conventional class it is very difficult for the teacher to address this problem since the capacity to assimilate knowledge can vary enormously from student to student. Ideally, each student should be allowed to study during their most efficient period of the day, be it mornings, afternoons or evenings and have enough time to assimilate knowledge at their own pace. While it is difficult to implement this concept in a conventional class because of time constraints, it is easy to implement with online training.

3.1. Solution: Flexible time frame to complete the mandatory training hours

The students are given an extended period of time to complete the mandatory hours. For example, the students have 60 days to complete a 40-hour training. Consequently they can choose the period of the day and the amount of time they dedicate to the online training every day.

3.2. Solution: Availability of the material

The students have at their disposal all the material previously covered. They can decide to look at a video animation several times over, pause the animation at critical points, go back to a previous explanation to make sure they understood the concept being presented or hone their interpretation skills by re-doing data analysis exercises.

3.3. Solution: Self-evaluation tests

At the end of each section students have access to a self-evaluation test to verify their understanding of the material covered in that section. Each question in the test has a link to the page explaining the theory underlying the question. A special link in the theory page enable the student to go back to the test.

4. Challenge: Various learning methods

According to *Teaching Through Modality Strengths* ⁽¹⁾ there are three main types of learning method: visual, auditory and kinesthetic. Most people learn through a combination of all three methods but have a predilection for one of them. For visual learners, it is easier to assimilate knowledge by watching a video or reading an explanation. For auditory learners, it is easier to assimilate knowledge by listening to an explanation or reading out loud a written explanation. For the kinesthetic learners, hands-on experience is key for easy understanding. A good online training must address all three types of learning methods in order to facilitate the learning process.

4.1. Solution: Video animations

If an image is worth a thousand words, a video animation is probably worth a thousand images. To better address the visual and auditory learners, video animations with voice-over and verbal transcript can be used. The animation itself is targeted at the visual learners, while the voice-over helps the auditory learner make sense of what he sees. A transcript of the voice-over helps both visual and auditory learners. Visual learners can use it as a visual reference for the voice-over explanation and auditory learners can read it out loud to revise the explanation.

4.2. Solution: Interactive exercises

PAUT is an eminently hands-on technique. To address the needs of the kinesthetic learners as well as to cover part of the necessary hands-on practice, interactive exercises are very important. Through an interactive environment providing instant feedbacks, the students can learn the fundamentals behind setups, calibrations, scanning and data analysis. The interactive exercises should use data from real calibration blocks and parts in order to familiarize the students with real applications.

5. Challenge: Limited attention span

The average attention span of an adult is about 20 minutes ⁽²⁾. Past this time, the students need to consciously refocus their attention in order to keep learning and not miss important information. Attention span is also a question of habit. Someone accustomed to manual work can have a good attention span while doing manual work but, sitting in front of a computer, his attention span can be reduced. This must be taken into account since PAUT is a hands-on technique.

5.1. Solution: Rotation between types of material

In order to keep all types of learners stimulated, a rotation between the different types of material can be implemented in the structure of the training. For example, a series of video animations followed by interactive exercises and a small movie about real life inspections. A full rotation should be kept under 20 minutes in order to maximize the results.

5.2. Solution: Mandatory pauses

Pauses are an essential part of learning. They give students time to relax and physically move around insuring that their attention is at a higher level coming back from the pause. The pauses should be dynamically generated by the server depending on the amount of time spent online by the student. For example, the server generates a 15 minutes pause for every 2 hours spent online. During that pause, the student shouldn't have access to the web site content.

6. Challenge: Mandatory training hours

Controlling the amount of time a student actually spend on online training can be challenging. A distinction must be made between the time spent logged-in and the time spent looking at the content of the website. A student can log-in on the website and go do other work. So, a mechanism to insure that the student is in front of the computer must be implemented. Equally challenging is controlling the identity of the person taking the final exam.

6.1. Solution: Use of timers

Since the time spent logged-in by the student is an unreliable measure of the real amount of time spent studying, timers must be used. Timers ensure that the student dedicates a predetermined amount of time on each page. The student does not have access to the next page until the timer reach zero. To ensure that the student is indeed sitting in front of the computer, when the timer reach zero the next page is not automatically displayed. The student must do an action, for example click on the button next, in order to have access to the next page. To prevent tempering, the timers should be based on the server's time not the student's computer time. Once the mandatory time has been spent on a page, this page should become available at any time without a timer.

6.2. Solution: Controlled environment

Because of its importance, the final exam should be taken under human supervision. Either in a controlled room where a human supervisor can control the identity of the candidate or in a remote room with the help of a streaming video camera.

7. Challenge: Various internet speed

As mentioned previously, in order to be efficient, an online training must have videos and interactive exercises. Furthermore, the quality of the videos must respect a certain standard in order to be pleasant to watch and the interactive exercises must be lag free. Since the speed of internet connections can vary enormously from region to region or country to country, it can be challenging to offer a high quality training to all.

7.1. Solution: Video animations

The goal is to have a video that takes less time to load than to look at. Since video animations are smaller in terms of megabytes than conventional videos for equivalent length and quality, they should be preferred.

7.2. Solution: Reduced data transfer and data compression

Steps can be taken to reduce the amount of information transferred for each interactive exercise. By using a program that uploads only once the common framework for all the interactive exercises, it is possible to minimize the amount of duplicate data transferred for each page. To lessen the amount of data transferred between the server and the student's computer, data file can be compressed on the server and decompressed on the student's computer. Using this method, data from real calibration blocks and parts can be used without scarifying downloading time.

8. Conclusion

Because of the complex theory underlying PAUT, considerable efforts should be put into developing a well-structured and interactive environment to fend-off confusion and boredom. A pleasant interface will also go a long way to insure a harmonious interaction between student and website.

Using the online technology available today, it is possible to develop a wide variety of interactive exercises and instrument specific simulators to successfully address the hands-on nature of PAUT.

References

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