



MODULE CODE: ECPT6006

**ASSESSMENT COMPONENT: A Critical
Evaluation of the Role of Digital Innovation in
Professional Practice**

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1. Introduction

Digital innovation has become a key part of the education sector globally, most significantly in sectors that rely heavily on data, automation, Industry 4.0 and simulation in the sciences and engineering settings. A significant part of these topics includes using technology, such as simulation to improve understanding of and solve complex problems. However, the assumption that digital innovation and technology enhance learning is somewhat contested (Bayne, 2015). Selwyn (2016) conducted a study of 1658 undergraduate students in higher education from two Australian universities, highlighting four key digital downsides to digital technology. The key themes were that technology can be a 'Distraction' diverting attention from students work with social media platforms being readily available on devices. 'Disruption' where the intended technology fails to function, causing delays and preventing students from learning. Disruption comes in many different forms such as internet outages, software failures system outages etc. 'Difficulty', some students may not be as computer literate as others having difficulty in learning how to use the piece of technology

Therefore, taking Selwyn (2016) concerns into consideration, the digital tool chosen must be easy to use, reducing the 'Difficulty' factor. The tool will also not require internet access when in use so that students may disconnect from the internet, reducing 'Distraction' and 'Disruption'. 'Detriment' is an important factor in learning (Selwyn, 2016); the student experience should not be linked to diminished forms of higher education where digital tools are used to compromise a learner's experience from physical interaction with teachers and equipment. To overcome the fear implementing a tool that will be detrimental to learners it is important here that a 'blended' learning approach is taken. This blended learning approach will allow learners to engage with the digital tool at a time when it is convenient for them to do so. The tool should enable learners to use the tool to provide a visual understanding of the subject at hand and increase their awareness and ability to perform a physical/experimental task following its use.

2. The role of creativity and Digital Innovation

2.1. Further and Higher Education Policy in Wales

University students are now experiencing a greater exposure to technology to develop their learning and measure progress throughout their studies. University and post 16 learners now experience a mainly digital ecosystem from enrolment, communication, assessment submissions, feedback and grading. This transformation reflects broader socio-economic change in which digital skills are increasingly central to the employability. The Digital 2030: A strategic framework for post-16 digital learning in Wales states the importance that learners must be equipped with the with digital competency they will need to succeed in life and a work environment (Welsh Government, 2019). This policy positions digital competence not as option but essential to modern education.

The framework acknowledges that the workplace will require adaptability with the ability to exploit rapidly evolving technologies (Welsh Government, 2019). For students in Higher Education adopting digital innovations in the classroom can serve as cognitive scaffolding and professional preparation for the workplace.

However, as previously discussed it is important for teachers and learners to recognise that the use of digital technology automatically enhances the learning experience. Angelli Genlott and Gronlund (2016) demonstrated that technology that is used without a coherent pedagogical method may negatively impact learning outcomes. There is clear evidence that caution should be taken when incorporating technology into teaching and learning.

For students developments in digital innovation can help enhance accessibility, flexibility and independence. The digital 2030 framework expresses flexibility, personalisation and immersive experiences as key themes in post-16 learning. In practice, simulation tools such as the one used in this assessment allow learners to manipulate parameters, visualise patterns and experiment in a safe environment before carrying out laboratory testing. This aligns with Prince's (2004) findings that active learning strategies improve conceptual understanding when compared with passive learning.

However, digital innovation and adoption also introduce ethical and accessibility challenges. Issues of accessibility and digital literacy may exaggerate inequity if learner lack the technological competence to reliably access and use the tool. An over-reliance on simulation could also inadvertently cause a lack of investment in physical equipment.

Within industries, emerging technologies such as AI and digital twins are increasingly integrated into workflows. Preparing learners for these developments could be considered a professional responsibility of a teacher.

2.2. Digital Innovation in Technical Education

Digital technologies are often presented as transformative within education; however, research suggests that caution should be taken when adopting technology (Selwyn, 2016; Bayne, 2015). Within engineering education, simulation has gained traction as a means of bridging theory and practice. Simulation-based learning allows learners to explore parameter alteration in low-risk environments.

2.3. Simulation in Education

Simulation based learning strategies are well established in field such as aviation and medicine, where high-risk scenarios require safe practice (Lateef, 2010). Education in subjects such as engineering over time has increasingly adopted this approach when complex problems, systems and or expensive equipment with limited access is an issue (Heradio et al., 2016). Analysis suggests that well-designed simulations can help improve the conceptual understanding of a topic/problem. This is especially the case when it is integrated into a structured pedagogical framework rather than used as standalone tools (Rutten, van Joolingen and van der Veen, 2012).

However, the effectiveness of simulation relies on cognitive and digital literacy factors. Heradio et al. (2016) note that simulation environments must balance fidelity and cognitive accessibility. Excessive realism can overwhelm learners, while over simplified simulations will not serve a purpose and can sometimes reduce understanding.

Considering Ultrasound and the tool used in this assessment where acoustic phenomena are abstract and no visible, simulation provides a visual representation of waveform behaviour, potentially bridging the gap between theory and observable data captured during physical testing.

The assumption that simulation produces an authentic learning experience remains in contention. Schön (1983) conception of the reflective practitioner emphasises learning through reflection-in-action. A digital learning environment that lacks variability may constrain this development. Therefore, the digital learning tool used should allow for variation of parameters and should be complementary to learning the subject and its phenomena not a direct substitute.

2.4. Learning Theories Relevant to Digital Simulation

Experimental Learning

Kolb's (1984) experimental learning cycle proposes that knowledge is built through a cyclic process of experience, reflective observation, conceptualisation and experimentation. For the topic of this assessment of Ultrasound, UT is typically taught initially through theory building a foundation of knowledge and understanding for the subject followed by practical demonstrations, and then finally learners experiment practically. However, learners often struggle with conceptualising the ultrasonic

behaviour with underlying acoustic principles and the results presented to them via the UT machine.

Utilising a UT simulation tool adds an additional layer allowing the learners to experience pre-practical experimentation with altering key parameters such as frequency, velocity, probe dimensions and flaw size/locations. This enables learners to visualise and make the connection between theory and experimentation gaining valuable experience. This additional layer should reduce cognitive overload and help contextualise the problem during physical testing. However, a limitation of the tool is that simulation does not provide feedback and environmental unpredictability, meaning that simulation should be used as a supplementary tool and not a direct replacement through a blended learning approach.

Constructivism and Active Learning

Constructive theory suggests that learners actively construct meaning rather than passively receiving information suggesting that learners should be given the opportunity to discover relationships for themselves that are inherent to the learning material, a technique often referred to as scaffolding (Bruner, 1966). Digital tools that allow for adjustment of parameters align strongly with this perspective, instead of learners being shown images of A-scans, learners can generate their own outputs through an iterative cycle. This can lead to reinforcement of theoretical learning for example identifying and visualising that increasing inspection frequency results in a greater resolution but can reduce penetration depth of the acoustic wave.

Constructivist learning environments require structured scaffolding. Without guidance learners may engage only superficially with the digital tool. To combat this a series of tasks that prompt learner to complete certain tasks may be beneficial to ensure proper use of the tool.

2.5. Pedagogical and Technological Adoption Frameworks

There are many arguments for and against the adoption of technology within a learning environment, therefore, digital technology should be used to aid teaching and learning only where appropriate. This means that teachers need to develop ways in which technology can play a role in learning only when it benefits the learners and has a pedagogical advantage. This ensures that learners benefit from the use of technology and that it is not just used for the sake of use. This is up to the teacher to determine and should consider a correct technology adoption approach such as the following:

- Replacement Amplification Transformation (RAT) – RAT is an assessment framework for understanding technology's role in teaching and learning practices (Hughes, 1998). This is where **Replacement**; technology serves as a different (digital) means to the same practices. **Amplification**; where technology

increases efficiency, effectiveness, and productivity of the same practices.

Transformation: where technology invents new Instruction, learning or curricula.

- SAMR – **Redefinition**; where technology allows for the creation of new tasks, previously inconceivable. **Modification**; where technology allows for significant task redesign. **Augmentation**; where technology acts as a direct substitute, with functional improvements. **Substitution**; where technology acts as a direct substitute, with no functional improvements.
- TPACK – A framework that aims for effective implementation of technology based around 3 primary forms of knowledge: **CK** – content knowledge, **PK** pedagogical knowledge and **TK** – technological knowledge. Where they all combine to form Technological Pedagogical Knowledge (**TPACK**). TPACK will be used in the following section of the report to justify the use of the digital tool.

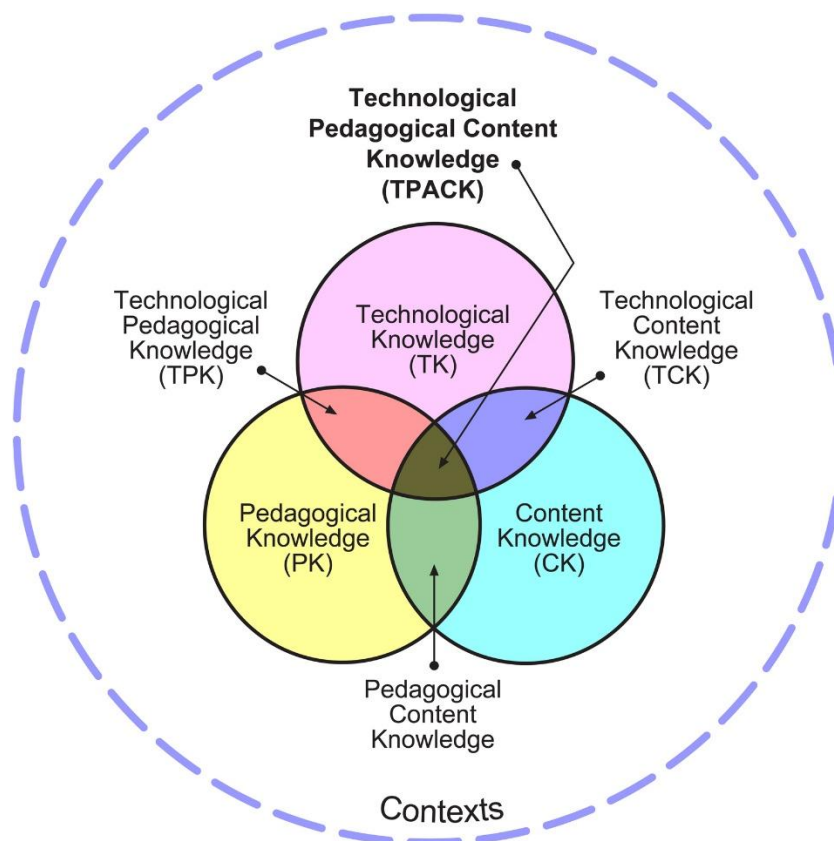


Figure 1 Image of the TPACK framework attributed to <http://tpack.org>

- TIM – Technology Integrated Matrix provides a framework for describing and targeting the use of digital tools and technologies to improve learning (Florida Center for Instructional Technology, 2005). The matrix consists of 25 cells as provided below in Figure 2

a more detailed description of the chosen TPACK method is given in section 3.3. of this report where it is considered for the technological tool adoption.

	 ENTRY The teacher begins to use technology tools to deliver curriculum content to students.	 ADOPTION The teacher directs students in the conventional and procedural use of technology tools.	 ADAPTATION The teacher facilitates the students' exploration and independent use of technology tools.	 INFUSION The teacher provides the learning context and the students choose the technology tools.	 TRANSFORMATION The teacher encourages the innovative use of technology tools to facilitate higher-order learning activities that may not be possible without the use of technology.
 ACTIVE Students are engaged in using technology as a tool rather than passively receiving information from the technology.	Information passively received more...	Conventional, procedural use of tools more...	Conventional independent use of tools; some student choice and exploration more...	Choice of tools and regular, self-directed use more...	Extensive and unconventional use of tools more...
 COLLABORATIVE Students use technology tools to collaborate with others rather than working individually at all times.	Individual student use of technology tools more...	Collaborative use of tools in conventional ways more...	Collaborative use of tools; some student choice and exploration more...	Choice of tools and regular use for collaboration more...	Collaboration with peers, outside experts, and others in ways that may not be possible without technology more...
 CONSTRUCTIVE Students use technology tools to connect new information to their prior knowledge rather than to passively receive information.	Information delivered to students more...	Guided, conventional use for building knowledge more...	Independent use for building knowledge; some student choice and exploration more...	Choice and regular use for building knowledge more...	Extensive and unconventional use of technology tools to build knowledge more...
 AUTHENTIC Students use technology tools to link learning activities to the world beyond the instructional setting rather than working on decontextualized assignments.	Technology use unrelated to the world outside of the instructional setting more...	Guided use in activities with some meaningful context more...	Independent use in activities connected to students' lives; some student choice and exploration more...	Choice of tools and regular use in meaningful activities more...	Innovative use for higher-order learning activities connected to the world beyond the instructional setting more...
 GOAL-DIRECTED Students use technology tools to set goals, plan activities, monitor progress, and evaluate results rather than simply completing assignments without reflection.	Directions given; step-by-step task monitoring more...	Conventional and procedural use of tools to plan or monitor more...	Purposeful use of tools to plan and monitor; some student choice and exploration more...	Flexible and seamless use of technology tools to plan and monitor more...	Extensive and higher-order use of tools to plan and monitor more...

Figure 2: Image showing the Technology integrated matrix by (Florida Center for Instructional Technology, 2005).

3. Selection and Justification of appropriate teaching tool/resources

3.1. The Pedagogical Challenge

When teaching Non-Destructive Testing from a physics and mathematical perspective especially UT there is a clear pedagogical challenge for learners where key areas where learners have found difficulties has been acknowledged through multiple years of delivery. Although adjustments to teaching methods and materials have helped improve these visible difficulties some of the followings are still present:

- Miss-interpretation of time-of-flight data (A-scan)
- Difficulty choosing a suitable inspection frequency
- Some miss-understanding why acoustic velocity is so important and inputting/calibrating with the correct velocity.
- Limited opportunity for repeated experimentation due to equipment/resource constraints. This negatively impacted the students learning as there is limited laboratory time, stunting students learning through iteration, experiments and mistakes.

Identifying these challenges that students face indicates a gap between theoretical and practical application. Through questioning, learners sometimes memorise relationships without fully understanding the implications it has on the physical outcome of their testing.

3.2. The Chosen Digital Tool

During the selection of the digital tool consideration of the pedagogical challenges above whilst reducing the difficulties and barriers faced by students as demonstrated in Selwyn's (2016) research and previously discussed in the Introduction section. The chosen tool is a digital representation of an Ultrasonic (UT) test used to take a thickness measurement of a sample with a single defect/ flaw. This tool is to be used to aid learning and not to replace the knowledge and calculations that govern UT and the digital tool. It is important that the theory and the physics/mathematics behind the tool is still covered in a lecture environment. The tool can then be used to alter parameters already covered in class and for the students to have demonstration of and help them understand the cause-and-effect relationship of altering each parameter. This would usually be done iteratively through a series of calculations undertaken by the students.

Given the limited availability of equipment and the safety critical nature of UT when conducted in industry a simulation tool was selected as a way of helping students bridge the gap between theory and practice helping students to conceptualise the problem prior to laboratory sessions so that students can best utilise the time spent in the laboratory. To meet the requirements of (Rutten, van Joolingen and van der Veen, 2012) a digital adoption framework is considered when implementing the tool into a learning environment.

Having a digital and visual aid will help students overcome the pedagogical challenges in understanding how to interpret the data of a UT A-scan when physical testing is carried out. The tool can be broken down into multiple sections within its GUI;

- **Parameters** – The section on the left-hand side of the GUI highlighted with a red box where there is a list of parameters that affect UT scanning of a component and its generated results. These parameters can be altered through a series of ‘Sliders’, ‘Drop-Down’ menus and by inputting values Figure 3.
- **A-Scan** – The section at the right of the GUI highlighted with a yellow box where the A-scan is displayed as seen in Figure 3 below
- **Schematic View** – The schematic view highlighted with a green box provides a visual representation of the chosen parameters driven by the probe diameter, Frequency, flaw type, flaw position and flaw depth shown in Figure 3.
- **B-Scan** – A B-scan highlighted with a blue box is data taken from the A-scan and transferred into what is usually described by students as a ‘better’ visualisation method of the data. Taking this into account it is important that the tool included this to help students visualise and interpret the data as in Figure 3.

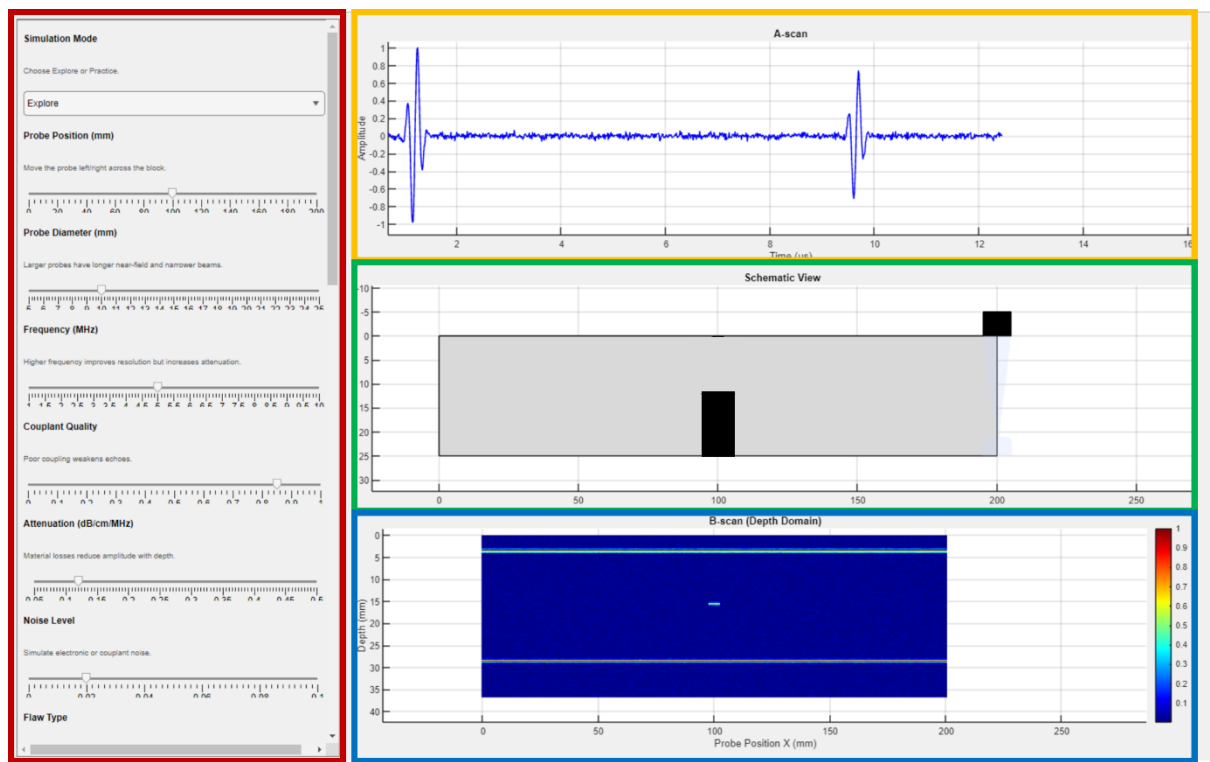


Figure 3: Showing an annotated screenshot of the digital tool chosen. **Red box:** shows the Parameters section. **Yellow box:** shows the A-scan view. **Green box:** Schematic section of the set-up. **Blue box:** B-scan view of the UT data collected.

3.3. Digital Adoption Model - TPACK

TPACK is a framework that aims for the effective implementation of technology into the classroom based on 3 primary forms of knowledge previously outlined as:

- **CK** – Content Knowledge
- **PK** – Pedagogical Knowledge
- **TK** – Technological Knowledge

The order is important because the technology that is being implemented must communicate the content and support pedagogy to enhance students' learning experience by differentiating between these three types of knowledge.

By distinguishing between three forms of knowledge, the TPACK framework demonstrates that content (what is taught) and pedagogy (how it is taught) must underpin any successful integration of educational technology. The order matters to ensure the technology exists only to communicate the content and reinforce pedagogical approaches, therefore improving the overall learning experience.

According to the TPACK framework, technological tools including software applications should be selected strategically to support student in developing a deeper and more comprehensive understanding of the subject matter.

Technological Pedagogical Knowledge (TPK) refers to the intersection between technological tools and teaching strategies. Pedagogical Content Knowledge (PCK) is the relationship between teaching approaches and specific learning goals.

Technological Content Knowledge (TCK) addresses how technology intersects with and shapes subject content. Together these interconnected domains form the TPACK technology adoption framework recognising that educators operate within a dynamic field where pedagogy and technology continuously influence one another in the modern teaching environment. Applying the TPACK framework with the chosen digital tool as follows:

Content Knowledge (CK)

The subject matter includes phenomena such as principles of wave propagation, frequency, wavelength, attenuation, reflection, refraction and mode conversion. Defect characteristics and A and B scan interpretation is needed before students can carry out practical inspection work therefore the CK is undertaken first in a series of 2/3 lectures to provide a base knowledge and understanding of the subject matter to students.

Pedagogical Knowledge (PK)

The tool is intended to be used in a blended learning scenario where strategies such as pre-practical exploratory learning, inquiry-based experimentation, visual learning

through A and B-scan interpretation and scaffolded conceptual development all apply by allowing students to engage with the tool both inside and outside of the classroom.

Technological Knowledge (TK)

The tool provides immediate visual feedback linking parameter changes to physical outcomes. The tool will initially be demonstrated to the class allowing for familiarisation and questioning before using the tool for themselves.

Technological Content Knowledge (TCK)

This is understanding how ultrasonic simulation represents acoustic phenomena. For example, when inspection frequency is increased in the simulation package it demonstrates reduced wavelength and improved resolution but results in increased attenuation and signal noise. Also, enlarging a defect and changing its position alters the signal amplitudes of the A and B-scans and the time-of-flight. The tool allows for an otherwise abstract construct visible and measurable. Without simulation student sometimes struggle to conceptualise these relationships before and during physical testing.

Technological Pedagogical Knowledge (TPK)

TPK demonstrates how the simulation tool alters the teaching and learning experience. The digital tool is present as a step between theory and practice. This allows students to become familiar with the concepts and explore what if scenarios without consequences such as damaging equipment. The immediate visual feedback from students can support active learning and quicken the learning process. The simulation tool allows for a shift from passive learning and instruction to exploratory analysis as previously discussed.

Pedagogical Content Knowledge (PCK)

This is where the lecturer (myself) determines how best to teach the subject at hand, in this case Ultrasonic theory. For example, using mathematics and physics formulas to explain reasons behind results and not just learning through a digital tool without understanding the fundamentals. Taking this into consideration it is important to build learning from first principles in a scaffolding manner before reaching simulation and experimental learning.

TPACK

The TPACK scenario is when all domains combine in the centre of the Ven diagram shown previously in Figure 1. Implementing this model allows for a deliberate use of the simulation tool in a learning environment. The tool is used to aid the understanding of acoustic physics through structures pedagogical strategies, with an outcome to

increase understanding and enhance practical competence of students and is considered one generating a lesson plan to integrate the tool.

4. Application of the chosen learning tool

4.1. The Tool – UT simulation

In this section the digital tool used will be discussed and shown in a series of screenshots captured while using the tool. Firstly, an image of the tool was previously presented with a short breakdown of each section was given in Figure 3. In this section a further breakdown of the tool and how it function is given. Figure 4 below shows the sliders can be altered to change each parameter of the simulation one or more at a time, such as frequency and probe position and diameter.

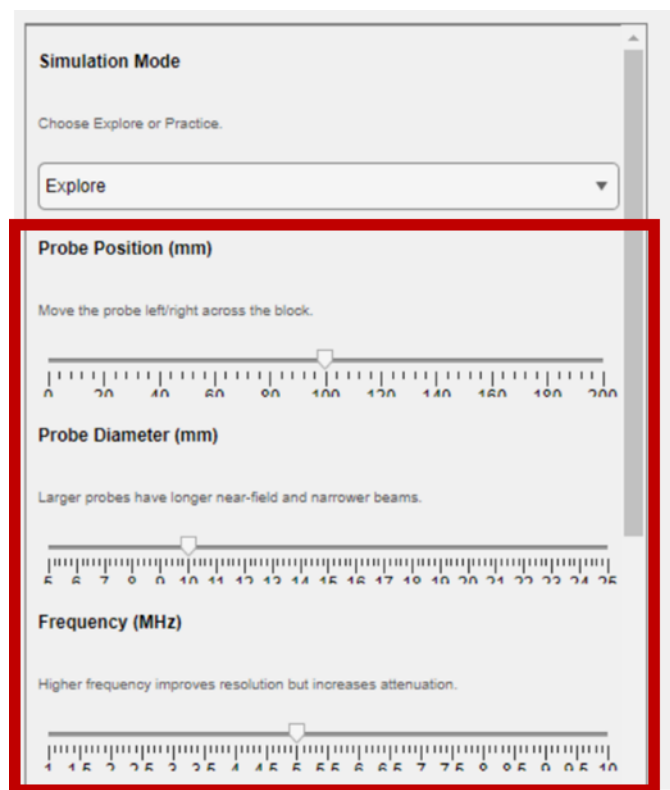


Figure 4: A screenshot of the UT simulation tool and how the sliders can be adjusted to alter parameters.

Once the parameters have been selected the simulation can be ‘run’ by pressing the ‘Start sweep’ button. This in turn automatically simulates the movement of the probe across the surface of the specimen shown in the schematic view with the results displayed in the form of a B-scan. Both the schematic view and the B-scan can be seen in Figure 5.

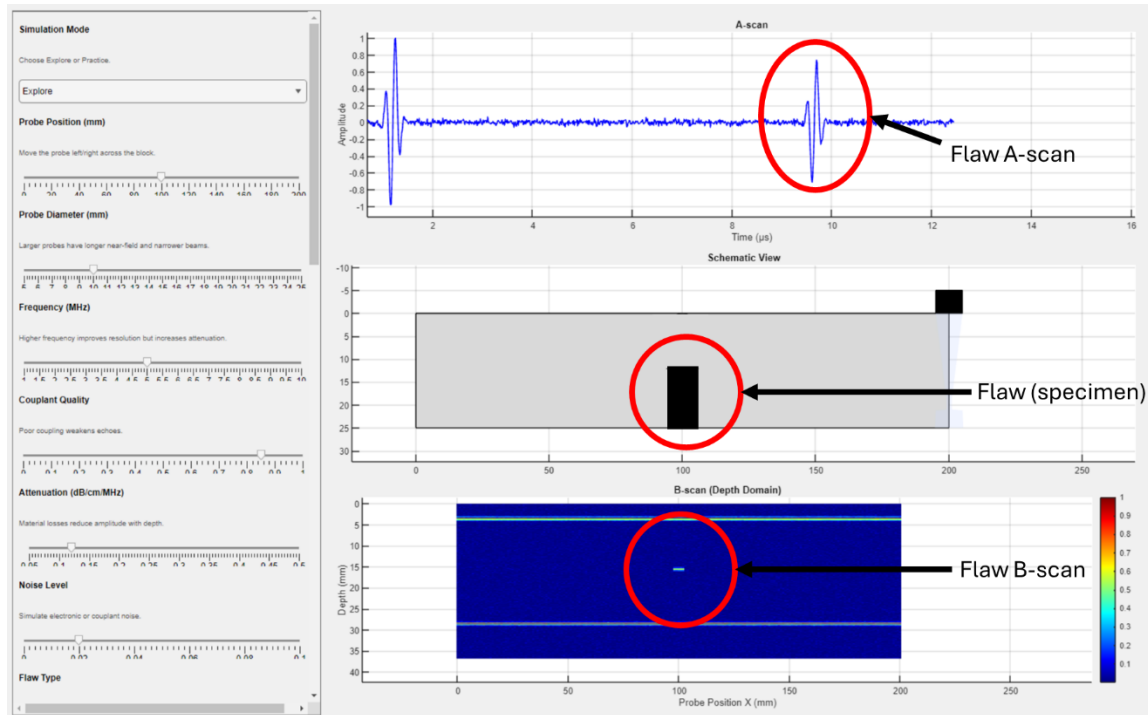


Figure 5: Showing the flaw present in the specimen/schematic drawing and as they present themselves in the form of an A-scan and B-scan.

The frequency in the simulation is reduced, and an image of the B-scan is shown to show the simulation 'in action' with a reduced amplitude response from the flaw and increased noise present is given in Figure 6.

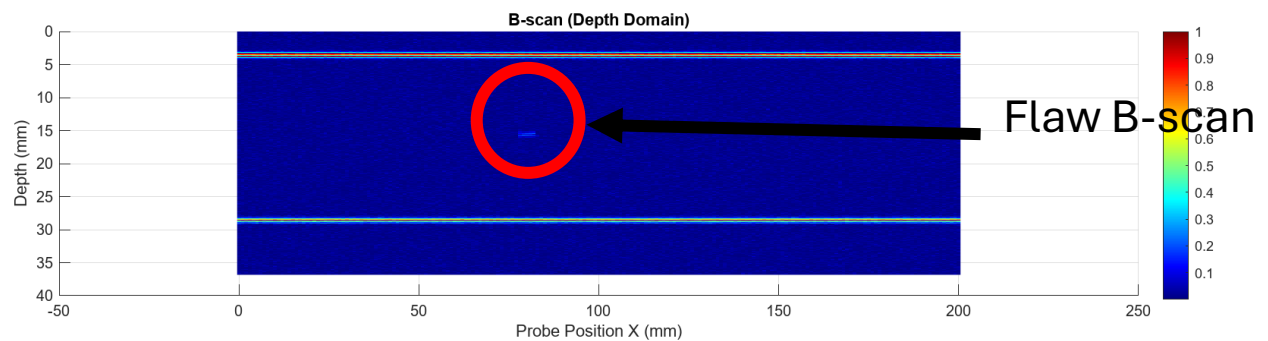


Figure 6: Showing the change in amplitude response from the flaw in the B-scan.

4.2. Lesson Plan

Here a lesson plan is given to demonstrate when this would fit into the teaching environment.



Lesson Plan

Topic: Microteach - Ultrasound		Class: Mechanical Engineering – Level 7	
Date: 08/01/2026	Length of lesson: 1 hour		Number of students: 4
Resources required: PowerPoint, PC with the digital UT simulation tool installed			
Aim of Lesson • Provide the students with a base line knowledge of Ultrasound. • Recognise the importance of know the speed of sound within a material and other governing parameters (see PowerPoint slides) • To give a basic overview of taking thickness measurements using Ultrasound simulation tool.			
Learning Outcomes – The Learners Should Be Able To: • Identify how UT takes measurements using the simulation tool • Demonstrate the ability to take thickness measurements using Ultrasound simulation tool • Identify the importance of the speed of sound within a material using the simulation tool			
Previous student knowledge required for the session: Base knowledge of Non-Destructive Testing, Including the core concepts behind Ultrasonic Testing where possible.			

Anticipated difficulties (if applicable):

Students may not have digital competency or devices to install the software. To mitigate these issues students are notified ahead of the session to bring devices and directed to loan devices where needed.

One group may complete the task quicker than the other. This can be overcome by having additional tasks for students to complete.

Equipment failure. If students' equipment fails or software issues occur students can group together and share a device.

Professional Standards (where are these being met within the session)

Value and promote diversity, equality of opportunity and inclusion – This will be met by providing each student the opportunity to take measurements using the Ultrasonic tool.

Plan and deliver effective learning, teaching and assessment - This will be met by ensuring I have practiced and recapped on the content provided in the slides prior to the lesson. A safe environment where learner can talk freely will be provided by stating this early in the lesson.

Demonstrate dignity, courtesy and respect towards other – This will be achieved by considering each student's needs and helping as required.

Lesson Detail:

Stage	Focus	Strategy	Time
Introduction	Introduce the topic and learning outcomes for the session, along with the practical task of using ultrasound to take measurements on metallic samples.	Lecture – (pp 1 – 2)	5 Minutes
	Provide the students with an overview of ultrasound theory basics to that they have a baseline understanding of what UT is, what it is used for. Show that materials have different speeds of sound. how measurements are calculated and displayed on an A-Scan.	Cognitive – Lecture & Questioning to gauge current knowledge of Ultrasound, even medical applications. (pp-3-8)	10 minutes
	Demonstrate the use of the UT simulation software, how to install and run the program. Then allow the students time to do so themselves.	Psychomotor - Practical – Digital competency Periodically check in on the students to make sure they are progressing in a timely manner. Q&A.	15 minutes

Plenary/conclusion	Once students have installed the tool and taken some basic measurements. The students will then be provided with a series of tasks that will take them through the using and altering the parameters within the tool. This will show the importance that Velocity has on taking accurate measurements along with frequency, probe dimensions and coupling etc.	Q&A on why the students think the measurements are different and reinforce the importance of the adjusted parameters and how they are affected.	25 minutes
	Recap on the learning outcomes and open the floor to any questions.	Lecture – Q&A.	5 minutes

Assessment Strategies: when and how are they included within the lesson?

There will be a practical activity where all students will take part in using the equipment. I will move around the room to ensure the students are completing the task correctly and help if needed.

The digital tool session will be followed by a Q&A to recall on the learning from the introductory section where the basics of Ultrasound is covered.

Q&A throughout the session

Informal reflection (to be completed after the session)

5. Evaluation and Reflection

Learners can use the tool outside of a lecture/laboratory setting such as at home to familiarise themselves with the fundamentals of Ultrasonic testing. The user can alter the main inspection parameters such as inspection probe frequency, probe width, material properties and dimensions etc as described in section 3. This will reduce the learners time needed to be able to carry out practical testing and reduce the strain on the limited resources available to learners.

Initial implementation of the UT digital tool only involved a small cohort of post 16 learners. Observations of learners having used the tool demonstrated improved A-scan interpretation understanding the back wall response and then responses from defects.

Learners found that altering parameters digitally with a visual aid, rather than mathematically increased awareness of how the physical system functions and produces its displayed results. This led to increased confidence when undertaking the task in a practical setting with students showing increased confidence in recognising changes in the displayed A-scan allowing students to correctly identify defects resulting in an increased Probability of Detection (PoD). PoD is a mathematical representation of how likely someone or a method is to find a flaw (Charlton, P; Granville, R) The tool also allowed students to immediately recognise the importance of system calibration, and the implications and incorrect measurements that could occur if this was done incorrectly.

The digital tool used requires students to have a reasonably high dependence on digital literacy, and having a device capable of running the package. This can be overcome by utilising the universities computer suits and loan of a laptop device where appropriate.

Digital Tool Strengths

- **Conceptual clarity** – Visualising waveform characteristics and how results change with altered parameters
- **Resource Efficiency** – Allows for repeated experimentation without material cost
- **Confidence building** – Learners can build confidence and undertake practical testing feeling more prepared.
- **Alignment with Industry and digital adoption policies** – Provides learners with a strong foundation using digital tools in work type environments

Digital Tool Weaknesses

- **Lack of physical feedback** – simulation cannot replicate physical probe movement and problems encountered such as rough and unpredictable inspection surfaces.

- **No experience moving the probe** – Moving the probe and using the correct amount of coupling takes time to perfect.
- **High dependence on digital literacy**

Taking into consideration the digital tool limitations it should therefore be considered as a part of a blended learning experience rather than a substitute to practical experience.

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