TEAM

Technology Enhanced Assessment Methods
in Science & Health Practical Settings.

Embracing alternative formats, assessment strategies and digital technologies to revitalise practical sessions in Science & Health

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A report commissioned by the steering committee of the
"Technology Enhanced Assessment Methods (TEAM) in science & health practical settings"
project entitled:

Embracing alternative formats, assessment strategies and digital technologies to revitalise practical sessions in Science & Health

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FOREWORD

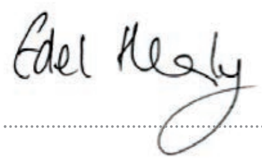
In Science & Health programmes, acquiring practical skills in addition to theory, is crucial to ensuring student learning and employability. The Institute of Technology (IoT) sector in particular places a major value on producing graduates who are 'workplace ready' with an emphasis on developing practical skills. It is widely recognised that assessment is an important influence on student learning, affecting engagement and motivation, effort and performance. The TEAM project aimed to develop a framework for applying the principles of good assessment and feedback to practical assessment and facilitate dialogue among stakeholders about what it is we want students to learn in practical classes and how our assessment can facilitate this.

The project focused on identifying and sharing best practice in technology supported assessment in Science & Health disciplines. This literature review provided the baseline of knowledge required to shape the direction of the project. Following this, through extensive consultations with all stakeholders, 4 priority themes were identified (i) Pre-practical preparation (videos, quizzes), (ii) Electronic laboratory notebooks and ePortfolios, (iii) Digital feedback technologies and (iv) rubrics.

The project team has involved academics from the 4 partner IoTs. These academics have lead the roll out of the TEAM project in their respective IoT with the support of their Heads of School and Learning and Teaching Units. A number of collaborative publications have already been obtained by the project team. A conference in March 2018 afforded the project team the opportunity to disseminate the final project outputs nationally to peers from the higher education sector. The intention is that this shall increase the peer network of academics in the Science and Health disciplines who have a shared vision for the development of enhanced assessment in practical settings.

Students, as partners, provided advice and guidance during each phase of the project and were central to its success. It is hoped the project shall lead to development of assessment consistency across modules, lecturers and partner colleges. Programmatic Review affords the opportunity for the learning from this research to be embedded in the assessment strategies of re-validated programmes.

On behalf of Dundalk Institute of Technology (DkIT), I would like to acknowledge the work of all of our colleagues from DkIT, ITS, ITC and AIT in contributing to the success of this very successful partnership. I would also like to thank our external advisor to the project Dr. Michael Seery, University of Edinburgh for his insights and support throughout. We hope this literature review of best practice in this field will be of value to academics who are involved in practical assessment in the Science and Health disciplines and that it will contribute to the further enhancement of the student learning experience. The financial support of the National Forum for the Enhancement of Teaching and Learning is gratefully acknowledged. Further details on the project are available at www.teamshp.ie.



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REPORT OVERVIEW

In science and health, the practical element of a module possesses the capacity to represent a powerful learning environment whereby learners can engage with peer learning, assessment, feedback, practical skill development and self-reflection. However, traditional practical session designs/formats with accompanying assessment strategies often prevail, remaining present in curricula, starving learners of opportunities to develop life-long metacognitive, technical and employable skills. This report outlines the role of the practical, addresses concerns with the traditional system, while at the same time presents practical and digital solutions for educators to employ that are capable of transforming and enhancing the practical learner experience. In this review of literature, five thematic areas for improvement have been identified, namely; (1) Design, Format and Practical Learning Environment; (2) Pre-practical Resources; (3) Assessment & Feedback, (4) Self-Assessment & Reflection and (5) Building Digital Capacity & Literacy. Engaging with the solutions presented within each theme has the potential to actively engage learners with practical sessions, while ultimately developing high quality and employable graduates armed with a suite of life-long metacognitive and technical skills.

Keywords:
Practical, laboratory, assessment, design, format, technology enhanced learning, digital literacy, assessment literacy, clinical skills.

Acknowledgements
The TEAM project steering committee would like to thank the stakeholders, namely the student partners, academic staff and employers, who have contributed greatly to the project. In addition, we would like to acknowledge funding and support from the (Irish) National Forum for the Enhancement of Teaching and Learning in Higher Education for this project (Enhancement Type B project stream).

THE TEAM PROJECT

To enhance student learning and employability in the science and health fields, the development of technical and soft skills is essential. Producing workplace-ready graduates is a key goal of the Irish Higher Education sector, with a current focus on developing practical skills. However, practical assessment practices at undergraduate level are still striving to meet their learning potential, with concerns over authenticity, over-assessment and graduate skill development often evident. The Technology Enhanced Assessment Methods (TEAM) project led by Dundalk Institute of Technology (DkIT) partnering with Athlone Institute of Technology (AIT), Institute of Technology, Carlow (ITC) and Institute of Technology, Sligo (ITS) is exploring and evaluating the potential of digital technologies in science and health practicals to address these concerns. Via engaging with stakeholders and evaluating technology based assessment approaches, the project aims to develop a framework to apply the principles of good assessment and feedback in the practical environment. Aligned stakeholder engagement will help determine what it is we want students to learn in practical classes and ultimately how our assessment choices can facilitate this.

For further information see: http://www.teamshp.ie

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TABLE OF CONTENTS

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1.0
INTRODUCTION

The Scholarship of Teaching and Learning (SOTL) recommends those in a teaching capacity research and focus on the quality of their students' learning and understanding while encouraging learner-focused conceptions with complementary associated practices (Boyer, 1991; Light, Calkins, & Cox, 2009). Boyer (1991) outlines how skilled educators facilitate active rather than passive learning, guiding and empowering their learners to become creative, critical thinkers who develop life-long learning skills to assist after their time in Higher Education. The implementation of multiple approaches aimed at developing specific skills and competencies in learners has long been a focus (Black & Wiliam, 1998; Boud, 1989; Dochy, Segers, & Sluijsmans, 1999; Taras, 2001). Promoting the development of life-long metacognitive skills such as self-evaluation and self-reflection in learners (in addition to educators) has become a primary focus in higher education.

This report focuses on the practical learning environment in science and health curricula, an element of learning which does not often receive its deserved attention when it comes to the design and assessment strategies employed. In many cases, traditional practical formats and assessment strategies regularly remain cemented in use, with changes rarely introduced. The goal of this report is to inform educators, by presenting an overview of the enhanced learning environment that can be created in a practical session, as well as a recognition for its potential as a key component for skill development. Engaging learners with student-centred activities via the implementation of different modes of learning, incorporating alternative assessment approaches while embracing digital technologies, can empower them with technical, practical and soft skills that can significantly enhance their employability and last a lifetime.

1.1

INTRODUCTION

In order to fulfil the goals of the SOTL, educators must be aware that the learning and teaching environment can be described as student-centred or learning-oriented, versus teacher-centred or content-oriented (Kember, 1997). Maintaining a teacher-focused environment, can cause students to become passive and adopt a surface approach to learning, while a more active, student-oriented approach has reported significant deeper approaches to learning (Biggs, 1999; Felder & Brent, 1996; G. O'Neill & McMahon, 2005; Trigwell, Prosser, & Waterhouse, 1999).

O'Neill and McMahon (2005) outline a model whereby both teacher-centred learning and student-centred learning are present at either extreme of a continuum rather than completely independent approaches, with lecturers deciding how far along the continuum one is able to move within the contextual barriers of the teaching situation. Expanding on this further, Elen and colleagues (Elen, Clarebout, Léonard, & Lowyck, 2007) comment on the creation of confusion when student-centred and teacher-centred learning environments are contrasted as being at opposite, extreme ends of a continuum, and present how they are better described as dimensions that are not independent, but rather closely related. They argue that rather than having the sole focus centre on the transition from teacher- to student-centred environments, there is a need for the development of 'powerful learning environments' (Figure 1) (Elen et al., 2007, p. 115). They go on to describe these learning environments as opportunities for learners to take full responsibility for the construction of their knowledge in a comfortable context, combined with targeted support from educators ensuring their approaches/activities prove effective.

Figure 1: The presence of a 'powerful learning environment' in which a continuum can be identified between teacher- and student-centred learning dimensions that are not independent, but closely related. Adapted from Elen et al. (2007) and O'Neill & McMahon (2005).

In the science arena, learners engage in courses that combine both lecture and practical elements with many educators viewing the laboratory as the essence of science (Tobin, 1990), while in health, clinical sessions are held in equal regard. Practical sessions are in place for learners to put theory into practice, and develop skills needed for doing a particular job or task. In the cases of veterinary and nursing environments, the Objective Structured Clinical Examination (OSCE), developed by Harden and colleagues (Harden, Stevenson, Downie, & Wilson, 1975), is the primary form of assessment in place. An OSCE represents a performance-based exam in which students demonstrate, and are assessed on, acquired practical skills. Here, the transfer of classroom learning experiences to simulated clinical practice settings are examined (McWilliam & Botwinski, 2002). One could refer to practical sessions as examples of 'powerful learning environments' outlined by Elen et al. (2007, p.115) with numerous benefits to the learner, as presented in Table 1.

Aspects of Education	Provide opportunities to...	Discipline Specific Tasks
Group Work	Solve problems	Formulate hypotheses
Assessment	Develop investigative skills	Data collection
Academic Writing	Construct relevant knowledge	Data interpretation
Practical Skill Development	Master practical techniques	Deriving appropriate conclusions
Peer Learning	Encourage creativity	Demonstrating practical competence
Implement Theory	Develop employable skills	
	Develop personal attributes	

Table 1: An overview of the benefits of the practical session.

Practical sessions allow students to obtain 'hands-on' experience of equipment/patients/animals ensuring the development of skills, understandings and personal attributes, in addition to encouraging creativity and employability skills (Knight & Yorke, 2006; Verran, 2009).
Hence, it is imperative institutions and educators consider the learning environment they create in practical sessions to facilitate the engagement of deep learning approaches and introduce opportunities for the development of metacognitive and other life-long skills in learners.

1.2 Practical Session Design & Format

There are numerous approaches to be considered when designing the format of a practical session. The most common format implemented is referred to as the *expository style* (See Table 2). Here, students are provided with a procedure and implement a deductive approach, whereby a general principle towards understanding a phenomenon, is applied (Domin, 1999). Advantages of this approach include opportunities for students to manipulate equipment, learn standard techniques, collect and interpret data and communicate findings in a report (S. W. Bennett & O'Neale, 1998; J. Dunne & Ryan, 2012). Discovery based approaches, also referred to as guided inquiry, do overlap slightly in that a procedure is often provided. However, the approach is inductive meaning by observing particular outcomes, students can derive a general principle (generally, reasoning from the particular to the general is referred to as inductive, while reasoning from the general to the particular is referred to as deductive (Arslan, Göcmencelebi, & Tapan, 2009). However, in contrast, students working with inquiry- and problem-based approaches will often develop their own procedure. While the most commonly used, the expository style is also the one most often criticised. In practice, students often repeat the educator's instructions and follow a defined, provided protocol to determine an outcome that is in many cases, known to both the instructor and the student. The students are regularly not required to think independently, reconcile results or do not encounter challenges - it becomes something Pickering described as naively predictable (Domin, 1999; Pickering, 1987).

Style	Outcome	Approach	Procedure
Expository	Predetermined	Deductive	Provided
Inquiry	Undetermined	Inductive	Student Generated
Discovery	Predetermined	Inductive	Provided
Problem Based	Predetermined	Deductive	Student Generated

Table 2: An overview of the general practical instruction styles: Adapted from Domin and McDonnell et al. (1999; 2007). See Bennett et al., p.90 (S. W. Bennett, Seery, & Sovegjarto-Wigbers, 2009) for figure of advantages and disadvantages of each style based on Domin's work (1999).

Inquiry based learning (open-inquiry) increases the level of student involvement as there is usually less direction provided by the instructor, there is an undetermined outcome and students are required to design and create their own procedure. This format provides the student with more ownership over the practical activity (Domin, 1999). The discovery style, or guided-inquiry, as with inquiry itself, is inductive in nature. It relies on the instructor guiding students towards discovering a certain outcome. The fourth style described by Domin (1999), problem-based learning, has become a very popular approach in practical settings. Here, instructors actively pose problems or questions to the students, while also making available the required materials. Students are often challenged with creating their own procedure to solve the proposed problem and submit a report outlining the procedure, results and conclusions (Mc Donnell et al., 2007). These learning strategies reinforce the earlier point, that educators must consider the learning environment being created in practical sessions. Being aware, and implementing particular strategies can have a dramatic effect on the learning experience of the student, in addition to metacognitive and communication skill development.

All programmes in Science and Health incorporate practical elements. For example, students studying nursing, midwifery or veterinary perform hands-on skills training in practical sessions learning the skills, knowledge and competencies directly related to professional practice. Similarly, science based students carry out activities in a laboratory on a weekly basis. Hence, with their importance in skill development and their role in learning, one would consider practical sessions to have always been effective. However, questions have long been asked of both the exact role of practical work in addition to the effectiveness of the sessions (Bates, 1978). While Hofstein and Lunetta (1982, 2004 p.29) reviewed earlier descriptions from the 1960s and 70s that the uniqueness of practical sessions being to provide opportunities for students '*to engage in processes of investigation and inquiry*', Roth (1994) reported the potential of practical sessions to assist learning of concepts and skills was yet to be realised. Currently, the expository style is often the approach most widely implemented. Here, students follow a procedure/protocol to obtain a pre-determined outcome or verify a known principle or law (S. W. Bennett et al., 2009). Its popularity relates to the scheduling of short practical sessions where a correct result is expected to be obtained, increases in student numbers in addition to a lack of funding or resources (Johnstone & Al-Shuaili, 2001; Lagowski, 1990). Often, the provided instructions in practical manuals overload the learners with excessive technical information and manipulative details, consuming most of their time, distracting them from the main goals and preventing the contextualisation of the practical to be considered (Hofstein & Lunetta, 2004). Due to time constraints on the practical session, learners have few opportunities for reflection and interaction, both essential for 'meaningful learning' to occur (Gunstone & Champagne, 1990). Meaningful learning requires a student possess some prior knowledge of a topic, material be meaningful and that the learner chooses to learn meaningfully (Bretz, 2001). In practical sessions, students could engage with this form of learning if the format is modified so that they can construct their understanding based on the results and findings obtained, be provided with the opportunity to critically evaluate the data and support any conclusions with evidence (Abidin, Zain, Rasidi, & Kamarzaman, 2013). This form of meaningful learning occurs across three domains; doing (psychomotor), thinking (metacognitive) and feelings, emotions and attitudes (affective) (Bloom, Krathwohl, & Masia, 1956; Emenike, Danielson, & Bretz, 2011).

In addition, there are limited elements of metacognitive activities built in to the practical sessions, limiting the opportunities for students to both develop long-term skills and feed their appetite to express the interpretation and meaning of their inquiry in the session. Incorporating time for interpretation, discussion, elaboration and application of one's learning, in addition to time for mental engagement to relate other learning experiences to practical work can lead to a greater understanding (Hart, Mulhall, Berry, Loughran, & Gunstone, 2000; Hofstein & Lunetta, 2004). In many cases, students can become fixated on merely following recipes, gathering data, obtaining the correct result and completing the practical as quickly as possible – all performed with no clear purpose of the investigation and the interconnections between all the elements (Hart et al., 2000; Hofstein & Lunetta, 2004). Thus, while the expository style can be used to develop, communicate and verify procedures or results in a practical setting, it is important to realise a shift in focus is required, a shift towards engaging the students in a learning environment that provides purpose and targeted support, time for interpretation and application, while also providing opportunities for mental engagement, reflection, discussion and other metacognitive activities. Gunstone (1991; Gunstone & Champagne, 1990) describe the need to ensure learners are encouraged to suggest hypotheses, ask questions and even design investigations with

'minds-on as well as hands-on'

(Gunstone, 1991 cited in Hofstein & Lunetta, 2004, p. 32)

1.2.1
Constructive Alignment of Practical Sessions

In any educational system, constructive alignment of the multiple elements is essential for success (Biggs, 1996). As discussed, the establishment and provisions of an appropriate learning environment is vital for students. This involves providing clarity about the purpose of the practical, the learning strategies to be used, the level of lecturer support, the provision of guidance material and the opportunities for discussion through peer to peer engagement and metacognitive activities. Each educational approach often integrates setting learning goals, determining assessment criteria and approaches and working in an iterative matter to continue to make adjustments to enhance student learning. While every practical session, be it an experiment in science or a skill development session in a clinical/veterinary environment, will have set aims and learning outcomes. The formalised aim of the science practical session/experiment details its goal, with information on the proposed end-point. For example, an aim could be 'To determine the molecular weight of an unknown protein using sodium dodecyl sulphate polyacrylamide gel electrophoresis (SDS-PAGE)'. Learning outcomes differ in that they outline what a student should be able to do, with the skill set a student would have gained by performing a specific practical session (Hussey & Smith, 2003; Stefani, 2009) . However, there is one other important aspect that is often overlooked – the 'purpose'. Hart et al. (2000) described the importance of the purpose of the practical being clear also, i.e. the lecturer's reasoning for why a particular practical is being performed at a particular stage of the course, why it is organised/delivered in a particular format and how it is intended to lead to student learning. Encouraging clarity on each of these aspects will assist in the format and delivery of the practical session, in addition to providing the student with a framework to build on within the session. However, once these are in place, there is another critical element that must be introduced for any practical session to be effective with regard to student learning – assessment.

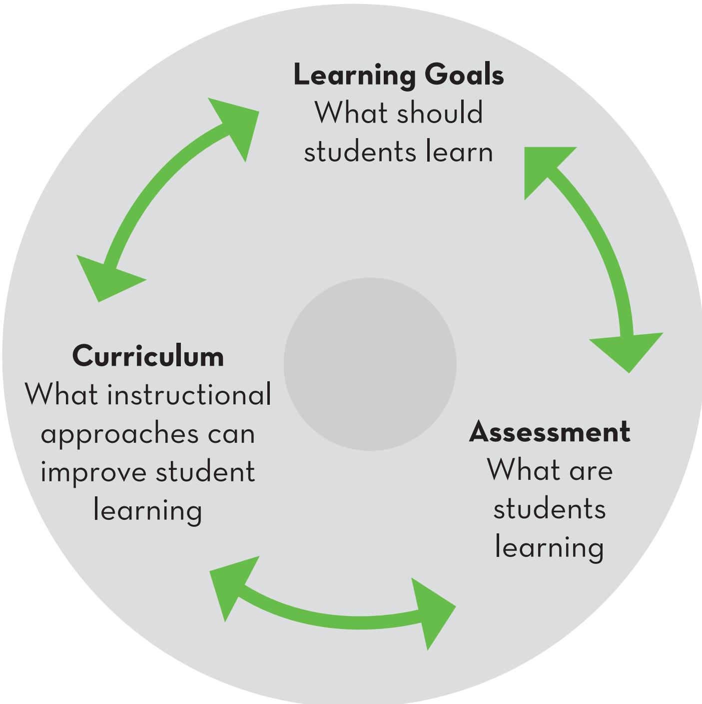


Figure 2: Connected Learning, adapted from the learning triangle adapted from Zwickl, Finkelstein & Lewandowski (2012).

2.0

ASSESSMENT 'OF' & 'FOR' LEARNING

'Assessment is at the heart of the student experience' described Sally Brown and Peter Knight (1994, p. 12) and history will most likely refer to the timeframe between the early 1990s and the present day as 'the assessment era' (Broadfoot & Black, 2004). The nature of implemented assessments have the potential to develop autonomous learners, motivate and build self-confidence while also influencing the way in which students view the learning process (Black & Wiliam, 1998; A. H. Miller, Imrie, & Cox, 1998; Prades & Espinar, 2010). Interestingly, students have noted a more positive experience when assessment for learning approaches are implemented, leading to a deeper approach to learning (McDowell, Wakelin, Montgomery, & King, 2011). The responsibility of setting appropriate assessment tasks that support learning and assist students in meeting the set learning outcomes for the practical lies with the educator (S. Brown & Knight, 1994; Fry, Ketteridge, & Marshall, 2009; Heywood, 2000; A. H. Miller et al., 1998; Palomba & Banta, 1999). Assessment methods are often differentiated by being either 'formative' or 'summative' in nature, while the terms 'assessment for learning', 'assessment of learning' and 'assessment as learning' are now gathering momentum. Most students are familiar from an early age with summative assessments, whereby assessment *of* learning is evaluated, summarising achievement, with a focus on reporting at the completion of a course of study for purposes of accreditation or certification (Sadler, 1989). Historically, many courses would have consisted solely of this assessment practice, a practice that has the potential to classify, daunt, limit the educational development of, and even impact on the emotions and self-esteem of students (Barnett, 2007; Dweck, 1999; Earl, 2003; Falchikov & Boud, 2007; Harlen, 2005). This focused educators on adopting transmission teaching styles, covering content and answering specific types of questions rather than implementing ways to use formative assessment to assist the learning process (Broadfoot, Pollard, Osborn, McNess, & Triggs, 1998; Osborn, McNess, Broadfoot, Pollard, & Triggs, 2000; Pollard, Triggs, Broadfoot, McNess, & Osborn, 2000; Reay & Wiliam, 1999). Hence, while it is essential those designing curricula ensure 'high stakes' summative assessments are not the sole assessment format considered in practical sessions, it is critical that assessment becomes embraced as a powerful learning tool, one capable of assisting learning through empowering and encouraging students. Thankfully, there has been a major shift towards

the combined implementation of assessment *for* learning practices, referred to as formative assessments – a strategy described by Bennett (2011) as certainly being in vogue, with it being a focus in teacher training and a theme at many education conferences. In fact, most current programmes employ this assessment approach. Nicol and Macfarlane-Dick (2006, p. 199) citing Sadler (1998) outlined how formative assessments are *'specifically intended to generate feedback on performance to improve and accelerate learning'*. Formative assessments, implemented in unison with feedback, have been given the role of empowering students, supporting building their self-confidence, motivation and developing self-regulated learners (Barnett, 2007; D. J. Nicol & Macfarlane-Dick, 2006). Self-regulated learners have the behaviour, thinking and motivation to assimilate feedback and drive forward their own learning, implementing strategies, feedback and managing resources along the way to achieve their learning goals (D. J. Nicol & Macfarlane-Dick, 2006; Pintrich & Zusho, 2002). These targets echo the works of Boud and Falchikov who outline the need for these skills for life-long learning, and careers after college (Boud, 2000; Boud & Falchikov, 2006). For formative assessment to thrive, it is important educators support the synergy or link between both formative and summative work and achieve a balance between both via complex and contextual thinking (Broadfoot & Black, 2004; Harlen, 2005; Price, Carroll, O'Donovan, & Rust, 2011). In general, it is critical that assessment interventions motivate and challenge students, stimulate learning and provide feedback (Price et al., 2011). Given the awareness of the importance of assessment, one would feel that assessment practices would be mastered at this stage, however a term coined in 2002 can still hold strong; the assessment of student learning can be the Achilles' heel of quality (Knight, 2002; Price et al., 2011) and therefore remains in need of significant attention in each element of the education environment.

3.0 FEEDING BACK TO MOVE FORWARD

In order for formative assessment to be even considered effective, the role of feedback cannot be underestimated. Hattie (2003, p. 8) referred to it as the

'single most powerful moderator to enhance student activity',

and subsequently as one of

"the most powerful influences on learning and achievement"

(Hattie & Timperley, 2007, p. 81). The authors refer to feedback as *"information provided.....regarding aspects of one's performance or understanding"*.

Traditionally, the term 'feedback' is often used to refer to constructive and supportive comments, suggestions, advice provided to students on a submitted piece of work aimed at improving the quality of the subsequent submission (Sadler, 2010). The provision of assessment feedback is what takes numerous hours of staff time and effort (Price, Handley, Millar, & O'Donovan, 2010). Overall, it is important to not only maintain an assessment focused view of feedback, as this can be limiting. A more contemporary view of feedback suggests that feedback should not only relate to assessed work but to all the feedback guidance (both formative and summative) involving lecturers, peers and tutors. This reframes feedback from being about transmission of information from lecturer to student to being a dialogic process which develops self-regulation (Y1Feedback, 2016, p. 13). Feedback has previously been referred to as '*feed forward*' by Bjorkman (1972) as students should use the suggestions to move forward and enhance their work. Feedback was aptly described as the

'oil that lubricates the cogs of understanding'

by Brown (2007, p. 1) and when implemented by students, has the power to improve learning and motivation while enhancing reflection and understanding (Merry, Reiling, & Orsmond, 2005). However, despite this level of importance, feedback can often be misunderstood or misinterpreted, or have a minor impact in each case, as there can be a subconscious weighting towards solely viewing the grade awarded (Chanock, 2000; Gibbs & Simpson, 2004; Hounsell, 1987; Sadler, 2010; Wotjas, 1998). Indeed, some (Carless, 2002; Gibbs, 2015; Sutton & Gill, 2010) would argue that a mark is not feedback and can be a distraction; and for feedback to be effective it requires students to respond to and make use of the feedback and that evidence of this occurring can be observed (Boud, 2014; Boud & Molloy, 2013).

"Information only becomes feedback when it is used productively"

(Carless, 2015, p.192).

Highlighting its importance further, Boud and Molloy (2013) recommend repositioning feedback as a fundamental element of curriculum design, one that translates to day to day practices, all aimed at developing student self-regulation.

In a recent report on practical assessment, the level of engagement with feedback was improved using an incremental/tiered marking system aimed at developing an 'always improving' mind-set in the students (Bree et al., 2014). However overall, there is potential for ambiguity in how feedback is delivered, received and interpreted (Price et al., 2010). Perceptions of feedback from both students and educators is important in addressing this issue - Weaver (2006) described that in order for students to engage with feedback, they may initially require guidance/advice on understanding and using it. For example, it is important that educators realise that more feedback does not always equate to more learning (Kulhavy, White, Topp, Chan, & Adams, 1985). From this educator viewpoint, Price and colleagues (2010) outlined how a content-focused approach to feedback often provides further knowledge in feedback, whereas an educator with a more facilitator-focused approach, will be more centred on the learning process and the development of metacognitive skills in the students. An aspect of feedback often indicated by students to be lacking is that of having more opportunities to engage in a dialogic process with staff. Carnell and others recommend the presence of a feedback dialogue where collaboration in the co-construction of knowledge can encourage effective learning (Bloxham & Campbell, 2010; Carnell, 2007; Carnell & Lodge, 2002; D. J. Nicol, 2010; Watkins, Carnell, Lodge, Wagner, & Wahlley, 2002; Yang & Carless, 2013). In fact, the absence of dialogue leads to the student never quite becoming fully aware of the input of the provided feedback to their learning, in addition to the educator not realising how the provided feedback is used (Orsmond & Merry, 2011). In summary, feedback is critical for student learning, however feedback must be effective if it is to assist the student and feed-forward in any way. Educators must open channels of dialogue on feedback with their students to determine the purpose of the feedback, while ensuring their feedback is clear, timely, legible, supportive with information on how to improve the submitted piece of work bearing in mind the effect of being either content, or facilitator focused. In order to avoid dissatisfaction in the process, there must be clear communication between the feedback-providing educators and the feedback-receiving students; an aspect that can benefit enormously via the presence of clear opportunities for feedback dialogue and the uptake and implementation of feedback (Bloxham & Campbell, 2010; Carless, 2015; Carnell, 2007; Carnell & Lodge, 2002; D. J. Nicol, 2010; Orsmond & Stiles, 2002; Price et al., 2010; Watkins et al., 2002). If sustainable feedback practices can be embedded to promote self-regulation, students may over time, develop an ability to seek and generate feedback for themselves (Boud & Molloy, 2013; Carless, Salter, Yang, & Lam, 2011; Winstone & Nash, 2016)

4.0

TRADITIONAL APPROACHES TO ASSESSING IN PRACTICAL SESSIONS

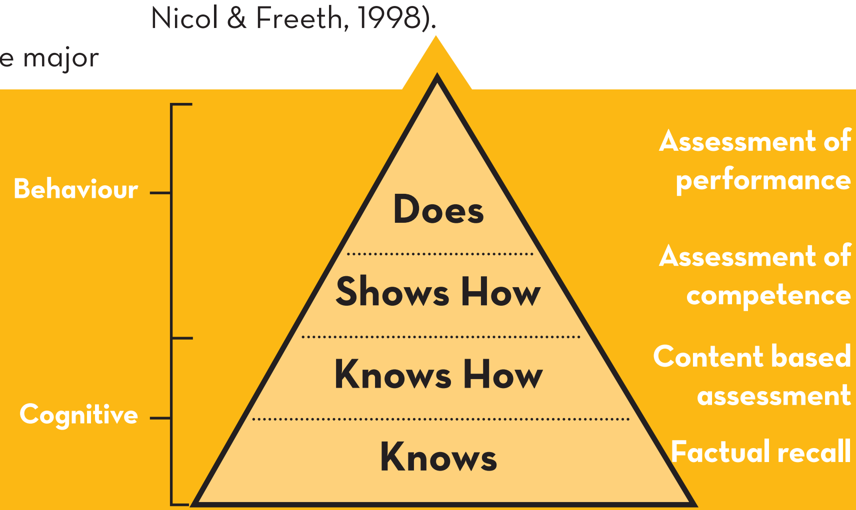
To date, this report has demonstrated the shift in education towards the generation of powerful learning environments in which students become empowered to actively play a key role in their own learning, engaging with constructively aligned assessment for, and of, learning approaches and generating an always improving mind-set through interacting with supportive feedback. At this point, it is important to identify the assessment approaches commonly used in the practical environment to establish a baseline for the general system often found in practice, remembering that assessment choices can determine how a student views the learning process (Prades & Espinar, 2010). Pickford and Brown and others (Hofstein & Lunetta, 2004; Mc Donnell et al., 2007; Pickford & Brown, 2006) address how students have become very assessment driven in the current culture, and that if assessment is neglected with less assessment given to certain elements such as practical skills, students assign less value to such approaches and believe they do not warrant attention. Hence it is imperative assessment options and interventions are considered and implemented correctly.

Traditionally, in the life science field, the traditional mode of assessment has been based on students preparing a formal laboratory/practical report, describing the experiment performed and results obtained, with the practical session regularly carried out in an expository learning style using recipe-like protocol cookbooks. In these hand-written reports, the student uses a set of traditional 'template' section-headings, of which many are familiar with from school programmes – aim, introduction, materials and methods, results, discussion and conclusion. There are numerous reports on how this summative mode of assessment remains overused causing a lack of student focus - measuring knowledge versus practical skills, relying on students' ability to record results, sharing of previous reports with future classes leading to plagiarism – while all the time leading to a high workload for both student and staff (Aurora, 2010; Bree et al., 2014; Hughes, 2004; Hunt, Koenders, & Gynnild, 2012; Mc Donnell et al., 2007; Pickford & Brown, 2006; Whitworth & Wright, 2015). Another report refers to the idea of students writing introductions (which normally identify gaps in published research and explain how their research fills that gap) for practical reports 'can only be a sham' as they need a more advanced knowledge of the literature and scientific ideas of their own, something they would not gain until a later stage of their undergraduate studies (Moskovitz & Kellogg, 2011). There is also a lack of standardisation with regard to report format

and correction between modules, i.e. different lecturers may have different requirements in the reports, leading to confusion for students (Bree et al., 2014). One must balance the practical report discussion with appreciation that they can ensure student engagement with literature when generating an introduction, demonstrate comprehension with experimental concepts, provide an avenue for improving scientific/academic writing with opportunities for academic feedback, allow recording and tabulating or graphical/diagrammatic presentation of experimental data in addition to the interpretation of the results obtained – all skills worth developing and required in the sciences. Timmerman, Strickland, Johnson and Payne (2011) also describe the laboratory report as a potentially '*rich source of information about students' scientific reasoning skills*'. Therefore, there certainly remains a place for the practical report, however whether it should represent the sole mode of assessment; whether it is required after every practical session and whether further standardisation is needed across modules and institutions are all points for consideration – while it is clear that alternative formats and assessment strategies are needed for further skill development.

From a health and veterinary point of view, practical sessions centre on students gaining hands-on, clinical skills directly related to practice. A key dimension of education in nursing for example, is via the enabling of practical skill development (Carlisle, Luker, Davies, Stilwell, & Wilson, 1999). These programmes often involve placements as part of the course, and during this placement a workbook is maintained and completed by the student with specific practical skills signed off as completed once they are acquired and performed competently. Assessment of clinical skills represents the major focus in the associated degree programme. Students' knowledge, practical skills and attitudes – and communication of same - are most commonly assessed using the OSCE assessment approach in a triple domain environment; affective, cognitive and psychomotor (Linn, Baker, & Dunbar, 1991; Newble, 2004; Rushforth, 2007). In an OSCE examination, students complete a multiple, consecutive station circuit where at each one a different clinical skill is assessed and a student is required to demonstrate a level of competency, during a defined period of time (Brosnan, Evans, Brosnan, & Brown, 2006; Hamadeh, Lancaster, & Johnson, 1993). Each student performs the same station circuit, ensuring the examination remains structured and objective to all involved (Oranye, Ahmad, Ahmad, & Bakar, 2012). Another benefit of the OSCE is their relevance and true to life nature, and students' awareness of this can drive learning (May & Head, 2010). Hence, even for distance learners, it is essential that OSCEs are applied in clinical skill evaluation (Oranye et al., 2012). Limitations of OSCEs in a veterinary setting were outlined by May and Head (2010) who reviewed concerns around only a selection of certain techniques being examined, with their fragmentation potentially compartmentalising these skills. In addition, Davis and colleagues (2006) discuss whether the ability to perform a skill in an OSCE environment is translatable to competency in handling a real case in a real situation (reflective of Miller's (1990) competency levels (see Figure 3)). Finally, there are reports describing the resource implications of running OSCEs, regarding space, staff, preparation etc. and how the process can evoke student stress and nervousness levels (Brosnan et al., 2006; May & Head, 2010; Muldoon, Biesty, & Smith, 2014; M. Nicol & Freeth, 1998).

Figure 3: A model outlining the initial levels assessed by traditional exams (knows/knows how) while the apex of the model (does) can only be examined in a real world clinical practice setting. The OSCE has the potential to assess at the 'shows how' level (Rushforth, 2007). Model adapted from Miller (1990)).



5.0
ALTERNATIVE FORMATS & ASSESSMENT STRATEGIES IN PRACTICAL SESSIONS

With the goal of ensuring practical sessions realise their potential and become effective, with a defined role in Higher Education, there have been a suite of reports centred on improving both the format and assessment of practical sessions. Johnstone and Al-Shuaili (2001) ask three fundamental questions that any educator needs to address when designing the format of practical sessions:

1. **'What are the purposes of teaching in laboratories/practicals?'**
2. **'What strategies are available for teaching in laboratories/practicals and how are they related to the purposes?'**
3. **'How might we assess the outcomes of laboratory/practical instruction?'** ***(Johnstone & Al-Shuaili, 2001, p. 42)***

5.1
ISSUES IDENTIFIED AND ALTERNATIVE APPROACHES FOR PRACTICAL SESSIONS

Firstly, it is important the philosophy of learning outcomes or objectives evident in programmes and modules be transitioned to individual practical sessions. The setting of learning goals combined with relevant activities and suitable assessment methods, for example see Henkel et al. (2015), can focus both the educator and the student, while providing context and a purpose for performing the session. However, it cannot be understated that learning outcomes need to move past knowledge development; and include development of problem solving, critical thinking, self-managed learning and interpersonal communication skills (Poon, McNaught, Lam, & Kwan, 2009).

As highlighted previously, in many practical sessions, students and lecturers can become pre-occupied with associated technical information, so much so, that this leads to a lack of time to perform meaningful, conceptually driven inquiry (Hofstein & Lunetta, 2004). In addition, students can become fixated on achieving the expected result that they miss the opportunity to relate other learning experiences to laboratory work (Hart et al., 2000; Saribas & Bayram, 2009). Practical sessions are meant to be opportunities for students to engage in the processes of inquiry, investigation, feedback, reflection and modification of their ideas (Barron et al., 1998; Hofstein & Lunetta, 1982). Practical sessions need to help them take control of their learning in the session (Gunstone, 1991; Gunstone & Champagne, 1990). It is imperative educators evolve and generate a 'powerful learning environment' for practical sessions (Elen et al., 2007), to ensure their potential can be reached. Tobin (1990) outlined learning as an '*active, interpretive and iterative process*'; practical sessions must consider and include these elements.

With regard to selecting the appropriate learning strategies (Table 2; Table 3), the expository style leads to students becoming familiar with constantly achieving successful results and lacking the ability to design practical approaches, problem solve or troubleshoot, while also rarely experiencing opportunities for metacognitive skill development (Caspers & Roberts-Kirchhoff, 2003; Roberts, 2001). Garcia

(2004) recommends that the inquiry style should certainly be involved in some capacity, while also suggesting the sessions should promote further social interaction. While the term inquiry based has a very broad meaning, Weaver et al., (G. C. Weaver, Russell, & Wink, 2008, p. 577) state the primary focus of this concept centres on *'engaging students in the discovery process at some level'*.

'Tell me, and I will forget
Show me, and I may remember
Involve me, and I will understand'

Confucius around 450 BC
(cited in Henkel et al., (2015))

Elements of Enquiry	Traditional lab experiments	Less open inquiry	⟷	More open inquiry
Observation				*
Questioning			*	*
Experimental Design		*	*	*
Data Collection	*	*	*	*
Data Analysis	*	*	*	*
Repeating			*	*
Reporting/Peer				*
Review				*

Table 3: The elements of inquiry and degrees of inquiry implementation. Adapted from Weaver et al., (2008).

In a study by Saribas and Bayram (2009), a guided inquiry-based approach was employed to create metacognitive awareness of the experimental format and design, allowing students to identify the problem, generate a hypothesis, design appropriate investigation approaches and explain the basis for their selection – with this approach employing a participating and active, versus passive and observing, role for students (Branan & Morgan, 2010; N. L. Donaldson & Odom, 2001; Sato, 2013). Stuart and Henry (2002) describe the excitement shown by students when they solve problems on their own describing the practical as becoming 'fun', as compared to merely following a 'cookbook' protocol in a mandatory laboratory they see as having no relevance to them. The term 'relevance' is important to be aware of when designing a practical curriculum (Hart et al., 2000). Henkel and colleagues (2015) implemented a real-life practical scenario that targeted solving 'real-life' problems. Their study allowed students to be in charge of their own experiment, to gain hands-on experience with equipment they would go on to use in employment after college, and to develop critical thinking skills. Each of the aforementioned studies echo the fact that undergraduate practical sessions must move away from the traditional, structured, memorisation themed instruction base to an experience learning base (Caspers & Roberts-Kirchhoff, 2003; G. C. Weaver et al., 2008). Caspers and Roberts-Kirchhoff (2003) describe their transition from structured practical sessions to a more project-based styled sessions. Here, their course commenced with a series of structured activities, aimed at developing the basic fundamental approaches. Once these were completed, students were posed with a research assignment, whereby they were responsible for searching and evaluating relevant literature as well as submitting and orally defending their proposals, carrying out the proposed experiment and ultimately submitting a final report. Willison and O'Regan (2007) presented their adaptable Research Skill Development framework, which they have used to monitor learner's skill development in research. The framework examines facets of inquiry and research at different levels from novice to expert, and when implemented learners identified and internalised research processes helping them "*to think that way for science*" (The University of Adelaide, 2016; Willison & Buisman-Pijlman, 2016, p.80).

There are other examples of where researchers have attempted to develop combination approaches, whereby students initially perform inquiry-based practical sessions on modern concepts and methods in first semester, while addressing an authentic, publication-grade, research question in the second (Gray et al., 2015). In this case, and others e.g. Roberts (2001, p.15), students reported a preference for the project based practical session and stated they learned more from them. Roberts summarises well when she states:

'The key is to allow the students to design their own experiments, working through any problems they encounter along the way. It is important to allow the students to experience some frustration while doing this and to refrain from "rescuing" the situation'

Thus, from an educator point of view, it is vital the implementation of suitable, or a variation of, modes of learning in practical sessions, being aware of how they are planned and structured can have a lasting impact. Many educators may envisage a large input of work with regard to restructuring their practical sessions, however this quote is worthy of consideration in this context:

'to change the experience, you don't need to change the experiment just what you do with it'

(S. W. Bennett et al., 2009, p. 184; Carnduff & Reid, 2003).

5.2
THE IMPORTANCE OF PRE-PRACTICAL EXERCISES

An area of education practice that has significantly gathered pace in recent years is that of pre-practical preparations, i.e. preparatory work students are required to carry out in advance of the practical (Agustian & Seery, 2017). Traditionally, students were asked to prepare for practicals by reading extensive text in practical manuals prior to attending – something many educators would argue, and many students would agree with, does not occur. However, perhaps it is the concept of reading through many pages of text which in some cases are not relevant; perhaps the text does not explain the purpose of the practical, failing to contextualise it for the student. Pre-practicals, for example using a brief video, can introduce students to key terms, facilitate students to establish essential background information, see new connections/linkages and realise their existing knowledge base will act as a sound foundation to assist in developing new linkages and learning – all reducing the cognitive load of novice learners (Johnstone, 2001; Sirhan, Gray, Johnstone, & Reid, 1999; Sirhan & Reid, 2001), echoing elements of the constructivist theory. Demonstrating their power, the implementation of pre-lecture resources in a study found there was no significant difference between students with, and students without, prior knowledge of the particular subject area (Seery & Donnelly, 2012). This study utilised online introductory eResources and quizzes prior to lectures to reduce cognitive load and facilitate in-class work. The results of this study certainly signify an important element to consider for all educators with regard to assisting first years settling in to new subjects in third level and improving student retention numbers. In separate reports, it was outlined how from a student point of view, completing a pre-lecture helped students feel more motivated, confident and gave them the ability to focus better in a lecture (McDonnell, O'Connor, & Rawe, 2012; Pogačnik & Cigič, 2006). With the observed benefits of pre-lectures, incorporating this concept in to the practical environment has been shown to equally benefit learning and hence worth considering for any practical curricula (Agustian & Seery, 2017; Brouwer & McDonnell, 2009). In one study, pre- and post-practical assessments were employed to assess whether learning outcomes had been reached (Henkel et al., 2015). Crowe, Dirks and Wenderoth (2008) developed a very useful tool that helps create and classify questions as per Bloom's taxonomy classifications (Bloom et al., 1956) and this was successfully implemented by Basey and colleagues (2014) when they implemented quizzes in practical sessions. The authors used the tool as they wanted to ensure that practical questions being posed were assessing both lower and higher order cognition learning in their study. A second resource worth consulting is that created by Carnduff and Reid (2003), where they present twenty pre-and post-laboratory activities for practical sessions. In a chemistry setting, use of the 'chemorganiser' pre-practical can have significant benefits for certain students who lack background experience, or those that took a break from a subject area and are returning (Sirhan & Reid, 2001). Here a template, structured document is completed by the educator with the problem, key information to know before commencing, key concepts, strategies, solutions, self-assessment and summary sections. Their goal was to bridge what the student already knew with what they were about to learn.

Therefore, the evolution of pre-lecture to pre-practical activities being implemented in any discipline represents a positive and engaging approach to motivate and focus students, while assisting them to perform better in practical sessions, stimulating learning and understanding overall.

5.3 UPDATING THE TRADITIONAL PRACTICAL REPORT

As discussed earlier, probably the most traditional assessment approach implemented in science and other fields, is often the formal practical report. With academic writing and theoretical learning being skills vital to acquire for a successful career, maintaining practical reports as a learning tool in some capacity is important to consider (Caspers & Roberts-Kirchhoff, 2003; Hunt et al., 2012). However, there are elements that with a simple restructuring process, could make it much more effective at the conceptual understanding and logical thinking levels (Hand & Keys, 1999; Keys, Hand, Prain, & Collins, 1999; Rudd, Greenbowe, & Hand, 2002). In this example, referred to as the Science Writing Heuristic (SWH), students are asked to complete a practical report, which encourages deeper thinking and understanding (Hand & Keys, 1999) after completing a guided inquiry based practical session (Table 4). Rudd (2002) report that in comparison with the traditional approach, the SWH method assisted development of conceptual understanding by relating learners' findings to what they already knew and understood. They found the students continued to make these connections, both in writing and in groups discussions. This echoes the quote presented in Section 5.1 that often '*you don't have to change the experiment, just what you do with it*' (S. W. Bennett et al., 2009, p. 184; Carnduff & Reid, 2003). Interestingly, the importance of the format of the practical session was also highlighted in this study, whereby if the students were more certain of the outcome of the session, they tended to revert to traditional behaviour identified by the authors, such as expressing less interest and accelerating through the procedure.

The Modified Science Writing Heuristic		
A	Beginning Ideas & Questions	What are my questions about this experiment?
B	Tests & Procedures	What will I do to help answer my questions?
C	Observations	What did I see when I completed my tests and procedures?
D	Claims	What can I claim?
E	Evidence	What evidence do I have for my claims? How do I know? Why am I making these claims?
F	Reading and Discussion	How do my ideas compare with others?

Table 4: The Modified Science Writing Heuristic. Adapted from Rudd et al., (2002) and based on Hand & Keys (1999) and Keys (1999).

There is also an alternative to assessing practical reports/notebooks that could increase their quality. The University of New South Wales (University of New South Wales, n.d.) suggest an open-book exam whereby students can respond to questions on the practical solely using their practical reports or notebooks.

5.4 IMPROVING FEEDBACK – DIALOGUE, DISCUSSIONS & UPTAKE

In order for written practical reports to be successful, there must be strategies in place to stimulate improvement and ensure learning outcomes are reached. Achieving these goals successfully centres on feedback. The introduction of simple approaches in to an educator's planning of practical sessions and feedback formats can have a powerful and lasting impact (See Table 5). Educators should use the opportunity provided by feedback to highlight what the student is doing correctly, and not only focus on any errors present.

In the case of medical, nursing and veterinary programmes which employ OSCEs to evaluate clinical skills, Direct Observation of Procedural Skills (DOPS) is regularly employed as a feedback providing mechanism (Norcini & McKinley, 2007). This process can ensure trainees are offered specific, structured feedback on both the interaction with patient/customer/animal and procedures performed based on direct observation, allowing improvement to occur. A benefit of this approach is that when feedback is consistent with the needs of the learner, its efficacy can be enhanced (Norcini & McKinley, 2007). This DOPS process can occur both during practical sessions in higher education facilities as well as in the placement workplace. This approach could be adapted to translate to a science environment when teaching practical skills.

Feedback Issue	Feedback Solution
Concern with lack of feedback uptake	Implement an incremental marking system to develop an 'always improving mindset' in students (Bree et al., 2014). Design approach to monitor feedback uptake.
Concern with lack of student engagement with feedback	Students may initially require guidance/advice on understanding and using it (M. R. Weaver, 2006). Developing assessment literacy in learners is key. This has the potential to improve engagement, motivate and support transition (S. Kift, 2015; S. M. Kift, Nelson, & Clarke, 2010; Poulos & Mahony, 2008)
Concern with lack of student engagement with feedback	It is important educators realise more feedback does not always equate to more learning. Various ways to sustainably improve its uptake must be considered (Carless et al., 2011; Kulhavy et al., 1985; Price et al., 2010; Winstone, Nash, Parker, & Rowntree, 2017).
Type of Feedback from an educator viewpoint	While a content-focused approach to feedback often provides further knowledge in feedback, an educator with a more facilitator-focused approach will be more centred on the learning process and the development of metacognitive skills in students (Price et al., 2010; Winstone & Nash, 2016; Winstone et al., 2017; Winstone, Nash, Rowntree, & Menezes, 2016).
Encouraging Learning with Feedback / avoiding dissatisfaction in the process	Incorporate feedback dialogue where collaboration in the co-construction of knowledge can encourage effective learning (Carnell, 2007; Carnell & Lodge, 2002; D. J. Nicol, 2010; Orsmond & Stiles, 2002; Price et al., 2010; Watkins et al., 2002).
Students and lecturers not realising feedback role	Incorporate dialogue to ensure students become fully aware of the input of the provided feedback to their learning, in addition to the educator realising how the provided feedback is used (Orsmond & Merry, 2011).
Assisting understanding feedback	Include a set-time in a practical session for feedback to be reviewed and discussed in groups; encourages its review & interpretation with opportunities for clarification (Orsmond, Merry, & Reiling, 2002, 2005).
Assisting feedback understanding and uptake	Consider one-to-one feedback sessions with student on laboratory reports written during the lab. While resource intensive, may be effective use of educator's time (O'Donovan, Rust, & Price, 2015).

Table 5: Matching feedback issues to contemporary studies. Incorporating these suggestions will add value for learners on how to interpret feedback, relate the feedback to the submitted work and also how to improve going forward (Sadler, 1998).

5.5
SELF-AND PEER-ASSESSMENT; ASSESSMENT 'AS' LEARNING

Aspects of student active learning highlighted by Denicolo, Entwistle and Hounsell (1992) was that students involved in sourcing academic meaning during their studies, took greater responsibility for their own learning and began to regard acquiring skills as a priority (Orsmond et al., 2002). Both self-assessment, where students assess their own work and peer-assessment, where they assess their colleague's work, have become recognised as 'assessment as learning' strategies that support learning (Earl, 2003; Poon et al., 2009). Self-assessing, which can ensure students reflect on their learning, is recognised as a life-long skill that can help them set their own goals while peer-assessment will assist in the constructive contributions in group, or collaborative, projects (Black & Wiliam, 1998; Boud, 1989; S. Brown & Knight, 1994; Hanrahan & Isaacs, 2001; D. J. Nicol, Thomson, & Breslin, 2014; Taras, 2001). Ensuring students can independently assess/evaluate their own work and make judgements on it with regard to meeting criteria/standards, in ways that are suitable to their future careers and professions has previously been described as invaluable (Boud, 1991; Stefani, 1994). David Boud (1990) described self-assessment as being fundamental to all aspects of learning while Boud (2000) and subsequently McDonald and Boud (2003, p.210) suggested the

"formal development of self-assessment skills is an important part of the curriculum at all levels".

Dochy et al. (1999) outlined that in order for specific competencies to be developed in students, there must be a plethora of methods in place to assist this goal. Implementing self-assessment strategies in parallel with encouraging students to reflect on their effort, work, accomplishments and feelings (and comparing and assessing these against the goals the student has in mind to be achieved) has the power to help develop problem-solving and self-regulating students (Dochy et al., 1999; D. J. Nicol & Macfarlane-Dick, 2006; van Kraayenoord & Paris, 1997). Even completing a self-assessment form requesting the strengths, weaknesses and areas for improvement has been shown to make students reflect on the quality of their submission and engage with their emotions (Bree et al., 2014). Another example of self-assessment, reflection, was described by Nicol (2009) where students compared their work against model answers.

Peer-assessment can refer to the grading of a submitted piece of work by a peer, while the term is also often used when referring to grading a group member's contribution to a collaborative group project. The former approach led students to state it allowed them to realise 'what markers are looking for', 'whether or not factors which must be in your essay are present' and to *'understand the strengths and weaknesses of your own assignment better when viewing the others' assignment on similar topic'* (Hanrahan & Isaacs, 2001, p.60). These findings echo those of Brown and colleagues (1996) who suggested peer-assessment helped students become aware of structure/layout and coherence of their work. However, in the same anonymous study, there were reports students *'felt uncomfortable about another peer reading my work'* leading to feeling *'pressured and awkward when writing my assignment'* in addition to the *'undesirable task of picking another student's work to pieces, and the thought of bringing their marks down'*. The authors conclude in their paper that the discomfort shown by some students about peer-assessment, for example being critical of others' work, some peers being overly critical and sensitivities around exposing their own work, all seem addressable by further training and practice.

Overall, both self- and peer-assessment do share commonalities; for example both involve students judging and assessing the quality of submitted work (Poon et al., 2009). With regard to lifelong skill development, their importance cannot be understated. However, if one is going to consider them in the practical arena and keep them reliable, it is important that students are trained in the use of these techniques through practice (Boud, 1989; Hanrahan & Isaacs, 2001). In addition, in the case of managing students to take self- or peer-assessment seriously, a criterion-referenced marking scheme or even pre-defined assessment system criteria is critical in conjunction with discussion at each stage of implementation to help understand the assessment process, leading to the development of assessment literacies (Hanrahan & Isaacs, 2001; Orsmond et al., 2002; Poon et al., 2009; Reiling, Merry, & Orsmond, 1997; Reynolds & Trehan, 2000).

5.6 RUBRICS

A rubric is regularly implemented to evaluate student work. It is often composed of three columns outlining the evaluation criteria, the quality definitions and a scoring process or strategy respectively (Popham, 1997; Reddy & Andrade, 2010). Quality definitions specify what a student must do in order to attain a particular achievement level, often ranging between poor and excellent (Reddy & Andrade, 2010). Task-specific criteria being assessed can be generated and presented as a rubric for research skill development, with educators being able to clearly state the criteria that can often be left implicit (Willison & Buisman-Pijlman, 2016). Rubrics can assist in the standardisation of the assessment process across different modules or lecturers while they can also be used to provide students with formative feedback on submissions, hence they can be classed as both evaluation and teaching tools (Arter & McTighe, 2001; Stiggins, 2001). Here, they can assist students in recognising and setting targets for their learning and assignments, clarify lecturer expectation as well as assist them in making reflective, evaluative judgements of their work that can lead to revised improvements (D. J. Nicol, 2009; Reddy & Andrade, 2010). However, in order to reap the benefits of rubrics as educational tools, students must be taught to use rubrics for self- and peer-assessment. Menéndez-Varela and Gregori-Giralt (2015) consider advocating rubrics not solely as scoring tools, but as complete teaching resources, even becoming objects of reflection in lecturer-student meetings. However, the authors do point out that taking this approach does require effort in their design and application but it would make them more useful and become closer to the reality of the education process.

5.7 ORAL & POSTER PRESENTATIONS

With the identification of an over-reliance on particular summative approaches in practical sessions, lecturers often attempt to vary the assessment methods. One common example of

this is an oral presentation as it represents a mode of improving oral communication skills, facilitates a way for groups to combine views/findings/understanding, in addition to the presentation and interpretation of data. For example, the presentation has been used in practical sessions which implemented mini-problem based learning approaches (Mc Donnell et al., 2007). Here, the authors complemented an oral presentation as a mode of assessment with project plans, reflective project statements and a project research diary. In many of the inquiry or problem based approaches, the students are empowered with responsibility for the design of the session, or experimental procedure in a practical environment. Hence, incorporating a group presentation provides an opportunity for students to outline their thought process on how conclusions were drawn. Here, the coherence of the group can be assessed, while the other assessment methods mentioned above such as reflective statements and research diaries, can assist in developing the students' reflective and self-assessment skill sets. Murphy and Barry (2015) had students self-mark their performance after reviewing a video-recording of their presentation, allowing the identification of feed-forward opportunities for improvement – an aspect capable of assisting the building of self-confidence ahead of future presentations.

Another form of presenting is that of a poster presentation, and this can be used to present a group project performed in a practical session. Preparing a poster echoes many of the advantages of the oral presentation with regard to skill development (Hughes, 2004), while producing a product to engage the reader visually. It essentially consolidates the learning into a specific bundle which can demonstrate the competencies achieved. From a career development approach, having students design a poster is worth considering, as long-term, the student will be armed with the skills needed to attend and present findings at conferences, and for their future career.

5.8
SKILLS BASED TESTS

The focus of many higher education institutions is to produce 'work-ready' graduates. To achieve this in the science and health disciplines, the development of a significant suite of relevant practical skills is essential (Hunt et al., 2012). In the health and veterinary disciplines, there is a primary focus on clinical skill competence. Assessment methods, such as OSCEs, centre on students demonstrating competency in a particular skill, being assessed on the process, practical delivery and communication of knowledge/understanding. The 'hands-on' skills being taught and assessed are each directly related to practice. However, in the science arena, excessive numbers of practical reports have been the predominant mode of assessment (Bree et al., 2014; Hunt et al., 2012). With students becoming more strategic towards their studies and assessment driven overall, their focus in science practical sessions moves towards the practical report, which is assessed, rather than the practical skills they are performing, which are often not being directly assessed (Pickford & Brown, 2006). In general, if certain aspects are not assessed, this can give the impression to students that the skills involved do not need to be taken seriously (Mc Donnell et al., 2007). Pickford and Brown (2006, p.75) present the following four questions to be asked when designing an appropriate strategy for practical skill assessment in a practical laboratory:

1. **Which practical skills are to be assessed in each practical?**
2. **Can any of these be assessed synoptically (i.e. integrated assessment)?**
3. **How is each practical skill best assessed?**
4. **Who among those available is best placed to assess the practical skill?**

While the authors admit these questions do appear 'obvious at first sight', they do present the point that often these questions receive little attention, and in science settings the practical report continues to dominate as the assessment method. Hence, these questions need to be considered when designing learning outcomes, learning activities and their associated assessment strategies. The concept of an OSCE-like, performance assessment is certainly one element worth introducing into the science laboratory environment, an approach that has been received positively in one study (Hunt et al., 2012). This has the potential to focus learners on the value and importance of developing practical, technical and competency skills.

5.9 THE PRACTICAL MANUAL & QUIZZES

Many practical sessions are often accompanied by a manual, containing relevant background material for the students or a corresponding procedure or protocol. However, the manual can often contain recipe-like protocols and overwhelm students with irrelevant background and technical information that adds confusion and prevents contextualisation of the practical itself (S. W. Bennett et al., 2009; Hofstein & Lunetta, 2004). Students are often requested to read the introductory material before the practical session, however in reality, this is rarely completed. Therefore, the practical manual represents an element in need of reform. There are elements the practical manual can incorporate such as the purpose of the experiment, explaining why a certain session is being performed at a certain time and how it corresponds to the lecture course. If inquiry based projects are being implemented, the manual can contain sample experiments to be used as guides, or information on reagents and required health and safety. There are examples of practical manuals being made more interactive, e.g. via exercises or the presence of quick response (QR) barcode links (Bree, 2017a; Bree et al., 2014). Here, in sessions where practical reports are not being performed, students test their understanding of the session by answering questions in the manual (in a formative manner). Lecturer sign-off and class discussions ensure the questions are completed. Many modules incorporate elements of this approach in a 'workbook', which the student completes during the practical session.
However, educators designing these questions, or indeed pop-quizzes, must aspire not to measure students' success based on recalling information, but more what they are able to do with the knowledge gained (Crowe et al., 2008). Crowe and colleagues (2008) developed the Blooming Biology Tool (BBT) to assist science educators constructively align assessments and enhance students' metacognition and study skills. The BBT is an extremely important resource to have access to and one that should be considered when designing practical manual questions, or quizzes of any sort, to ensure all aspects of Blooms taxonomy are addressed. Earlier in this review, the importance of preparation prior to the practical session was outlined. Often, this preparation is linked to brief quizzes (Suchman, 2015) – an addition that could encourage student participation in pre-laboratory activities such as viewing videos for example. However, while useful, educators must not become over-dependent on Multiple Choice Question (MCQ) based quizzes, as if students realise the mode of assessment is continually MCQ based, their learning will become focused on memorising or recognising appropriate facts or terms instead of an in-depth understanding of the underlying concepts (Heyborne, Clarke, & Perrett, 2011; Qu & Lu, 2012). Free-response, open-ended questions from higher levels of Bloom's taxonomy and the BBT require students to be able to understand and apply their newly gained knowledge (Bloom et al., 1956; Crowe et al., 2008; Heyborne et al., 2011), further assisting metacognitive engagement.

5.10 PORTFOLIOS

Portfolios are growing in popularity across disciplines, often being associated with demonstration of improvement and personal development. In the health care profession, they were introduced to diversify from the snapshot examinations (Haldane, 2014). The incorporation of portfolios can also allow assessment of aspects difficult to assess by other means, namely personal attributes, professionalism, attitudes and reflection (Davis & Ponnamperuma, 2006). Definitions of portfolios often stress the collation of work that includes a reflective narration or personal commentary (Arter & Spandel, 1992; Baume, 2001; Forster & Masters, 1996), elements often not incorporated in practical reports.

In this section, several aspects to practical assessment have been presented. While some educators may see one element to introduce in to their programme, Hunt et al. (2012, p. 17) present this important quote from Bamber, Trowler, Saunders and Knight (2009) stating how:

'changing only an element at one level may have limited, local and provisional success... because the rest of the system is not touched and established patterns prevail over the single change'

(2009, p.3).

Therefore, it is essential to consider systemic changes to both the format and assessment strategy of practical sessions in order to reap their benefits.

In the current digital era, there are numerous technology based interventions that can assist learning, with educators regularly introducing these approaches to their classroom. Embracing digital technologies and literacy in the practical environment is one area certainly worthy of attention.

6.0
TECHNOLOGY ENHANCED ASSESSMENT METHODS (TEAM)- EMBRACING THE DIGITAL ROADMAP

In Ireland, the National Forum for the Enhancement of Teaching and Learning in Higher Education published a report, described as a roadmap, for enhancement in a digital world (NFETL, 2015). The report suggests that digital capacity development, in order to support and enrich vibrant learning strategies, must be embraced and utilised more. The National Forum has funded numerous technology-based projects, such as "AllAboard" (2017), "TEAM" (2017), "TELU" (2014) and "Y1Feedback" (2016), with each initiative representing strong examples of contributions towards preparing students for digital learning, working and for living – nicely complementing JISC's mission of developing digital literacies (JISC, 2014).

Implementing new Information and Computing Technology (ICT) technologies can *'enrich teaching, improve learning experiences, support personalised learning, facilitate access through distance learning, and virtual mobility, streamline administration and create new opportunities for research'* (European Commission, 2011, p. 6). Hence, it is critical for digital strategies be incorporated in to curricula, and used for assessment. This section outlines some of the approaches by which technology can be introduced to enrich learning in the vibrant practical environment.

6.1
TECHNOLOGY ASSISTING PRACTICAL SESSIONS

As presented in Section 1.2, the format of the practical session is critical for meeting the learning targets set. Engaging students in each session is essential. While the inquiry based approach can really empower students with responsibility for their learning, one can always consider technology to assist before, during or even after the practical session itself. Technology elements can be incorporated for direct assessment of learners, or also as tools to assist facilitate understanding and future assessments.

6.1.1
Classroom Response Systems, Quizzes and 'Apps'

Classroom response systems (CRSs), often referred to as 'clickers', represent a relatively recent addition to the education environment with students being provided with barcoded CRS devices for use in classes or practicals. Clickers resemble the device used when a contestant goes to *'ask the audience'* in the game show *'who wants to be a millionaire'*. Educators can use these devices for numerous interventions (general use is outlined thoroughly by Caldwell (2007)). There are several reports outlining the positive benefits of clickers in the classroom (for example DeBourgh, 2008; Jones, Henderson, & Sealover, 2009), with some focusing on large class sizes (Mayer et al., 2009) and others taking the clicker in to small groups and practical environments (Sevian & Robinson, 2011). Caldwell (2007), echoed by O'Brien (2017), mention clickers can be used to assess or evaluate student preparation through questions regarding home exercises; or appropriate to this review, complement pre-practical tutorials; pre-practical questions; questions to guide thinking and review preparation for practicals. Students have commented positively on the use of pre-practical quizzes, stating their role in developing an awareness of what was taking place in the upcoming practical (Bree, 2017b; J. Dunne & Ryan, 2012). However, Sevian and Robinson (2011) detail the challenges of introducing clickers in practical sessions. With practicals involving 'hands on' activities, it is often difficult to halt a session for clicker use. The authors recommend the use of clickers at the beginning of practical sessions (to assess preparation) or at the end (to assess what has been learned), rather than interrupt practical exercises, stating *'care must be taken not to spoil the thrill of discovery'*. Walgren (2011) added a new, non-quiz based, activity involving new generation clickers in which numerical data can be entered, so that practical data could be captured from physics laboratory sessions by the students. When considering quizzes, questions can be designed to both generalise practical findings to assist in students applying them to different scenarios and also to include the multiple levels of Bloom's taxonomy (Crowe et al., 2008; Eisenkraft, 2003). It is important to ensure there are open ended questions present in any quiz, as MCQ tests are often related to superficial memorising rather than developing deeper understanding (Heyborne et al., 2011; Qu & Lu, 2012). In recent years however, the use of clickers has been replaced by smartphone applications (apps), and even by virtual learning environment utilities (such as Moodle Quizzes). A high percentage of students can now access the internet or download apps on their smartphones, and this allows tailor-made apps to be accessed. For example, the use of Socrative (http://www.socrative.com) , an app/website allowing cloud-based quizzes to be created, has been shown to enhance the learning environment for students and improve interaction (Dervan, 2014). As with clickers, implementing Socrative quizzes at the beginning, or end, of practical sessions can assess preparation, understanding and application. There are numerous other technology based quiz/interaction tools that can be incorporated, some of which were summarised by Donaldson (2016), (Table 6).

Application/Tool	**Description**
Kahoot https://getkahoot.com/	Can be used for live tracking quizzes, surveys or discussions.
Zaption https://www.zaption.com/	Create engaging video lessons online with in-play questions, text, images and discussions.
Answer Garden https://answergarden.ch/	Generate a visual display to a question where all responses collected. Show answers to questions/points for discussion/feedback.
Quizalize https://www.quizalize.com/	Generate quizzes and monitor progress, strengths and weaknesses to identify areas and students requiring further help.
Zeetings http://about.zeetings.com/	Broadcast and present to participants in real time. As the instructor updates the screen, the update is seen by participants on their devices. Opportunities for engagement (polls, quizzes etc.) are also possible.
Padlet https://padlet.com/	Create a flexible, digital canvas for projects to be shared or collaborated on. Participants can add text, images, video, documents to a padlet. Essentially acts as a customisable, digital bulletin board.
Quizizz http://quizizz.com/	An interactive and fun online quiz program, which can present quizzes in the form of a game.
Edpuzzle https://edpuzzle.com/	Allows presentation of videos to students that can be adapted to include audio notes and MCQ tests (with customisable feedback provided). Engagement and MCQ results can be monitored.

Application/Tool	Description
NearPod https://nearpod.com/	Allows educators to create interactive classes, including the ability to share content and perform assessments in real time.
Mentimeter https://www.mentimeter.com/	Allows real time voting with smartphones during presentations, allows for the creation of constructive discussion.
Plickers https://www.plickers.com/	Allows real time collection of formative assessment data without the need for student devices. Tailored feedback can be provided instantly. Best used for quick checks of conceptual understanding.

Table 6: An overview of some key Apps that can be used for engaging and interactive activities in both the classroom and the practical. Adapted from Donaldson (2016).

6.1.2
The Era of the App

Within every practical approach, there are apps available that can assist with the process. Table 7 outlines some apps worth considering for an educational environment with some having applications in practicals, and a brief description as to the functionality of each one.

App	Overview
Dropbox	Dropbox is a free app that allows file sharing and collaborative editing of shared files. This app is quite useful for students for collating documents in group or team projects, in addition to individual storing of electronic files.
Explain Everything	An app designed to create and record tutorial videos or images. Very simple to use on a tablet device.
Socrative	Quiz design app. Quizzes can be easily created on socrative.com and the students can download a Socrative student app to perform the quizzes and receive immediate feedback.
Google Docs	Google allows access to document sharing via its google drive. Students can access documents, spreadsheets or presentations and make edits in real-time. Another superb facility for document sharing with students to gather their input.
Laboratory Timer	In science laboratories, timing experiments is essential. This app allows multiple timers, which can be named, to be running simultaneously. Great for monitoring progression of several tasks at once.
Microsoft OneDrive	An online interface available to students via their Microsoft 365 account, to remotely back-up and share documents, in addition to working collectively in groups on shared pieces of work.

App	Overview
CloningBench	A wealth of analysis tools for the molecular biologist. Capable of determining all aspects of DNA quantification equation work, mastermix calculations, insert to vector ratios.
Oxford Handbook of Clinical and Laboratory Investigation	A guide to investigative techniques written by active, experienced clinicians.
Dilution	Calculates amount of one neat solution and diluent required to make solutions of particular concentrations.
Davis's Laboratory & Diagnostic Tests with Nursing implications	Contains hundreds of diagnostic test descriptions to help understand and implement critical test procedures.
YouTube	Educators can establish their own YouTube channel to ensure videos of interest (or indeed reusable learning objects created by the educator), for pre-practical activities/post-practical summaries are available for students to view via the web or the associated app.
Mendeley	App to access a Mendeley account (a free to use, very user-friendly reference manager). Educators could create a group and invite practical students. Within that group, the educator could place peer reviewed papers for review to assist the practical session.
Desmos	A free online graphing calculator.
Scrumwise or Trello	Project/group management software platforms, ideal for group/team based work.
UniDoodle	A classroom response system app that allows students to submit sketch based answers via their smartphones.

Table 7: An overview of a sample of apps to assist practical sessions and their associated work.

An excellent, award-winning, education app resource was generated by Dublin Institute of Technology (DIT)'s Dr. Frances Boylan and Trevor Boland (The 12 Apps of Christmas) (Boylan, 2014; Boylan & Boland, 2015). The Christmas timed release provided twelve apps to assist both educators and learners introduce technology in their teaching, learning and assessment practices. The project outlined how each app can be used to assist both learning and teaching.

6.1.3
Anatomy in your pocket

In recent years, one field of technology which seems to have advanced significantly is that of anatomy, often being shown in product demos. For example, the anatomy app '3D4Medical' was used during the Apple iPad Pro launch in 2015. This app has been highly recommended by numerous reports, with some praising its anatomically accurate models and 3D rendering capabilities (DiPaola & Orrin, 2013). With many science students performing dissections during their training, and many health care providers aware of body anatomy, these apps can act as tools to assist learning. For example, a stylus can take the place of a scalpel, allowing digital 'incisions' to be made. Previously in 2011, Mark Campbell established 'Pocket anatomy' to alleviate problems with patient-doctor communications (patients were retaining just 14% of what was being said by the doctor) (Ahlstrom, 2014). Development of anatomy apps such as those mentioned above, added to their initial goal of doctor-patient discussions with new education roles.

6.1.4
Interacting with Wikis - practically

A wiki, originating from the Hawaiian word for *'quick'*, represents web pages that can allow independent or collaborative creation of information with each edit traceable (M. E. O'Neill, 2005). While wikis have been in existence since approximately 1995 (Leuf & Cunningham, 2001), they have gone on to become a key web 2.0 element in many fields, such as education, for collaborative learning (Web 2.0 refers to the read/write mode of the internet, as opposed to web 1.0, which involved only reading) (Ruth & Houghton, 2009). In a faculty diary web-post from Dublin City University (DCU), Tim Downing implemented individual wikis with computational biology students (Downing, 2016). In this example, students were provided with instructions and links for each practical, as well as access to their own wiki page where results could be inputted. By the end of the session of practicals, students had amassed a large amount of data for a summary assignment. In many cases, the use of wikis has been described as win/win for both educators and students, allowing topic-driven avenues for communication to be designed, populated with options for assessment and feedback possible (Downing, 2016; M. E. O'Neill, 2005). Wikis have also been reported as useful tools in learning and assessment in microbiology practicals, promoting collaborative work, peer-assessment and developing a *'quest for excellency'* (Sampaio-Maia, Maia, Leitao, Amaral, & Vieira-Marques, 2013), while Ben-Zvi (2007) used wiki approaches for assessment, self-reflection and discussions. Even though wikis can appear like a 'one-stop-shop' for success with technology enhanced learning, it is essential their design is considered pedagogically. It is worth being aware of the work from Zheng, Niiya and Warschauer (2015) who prepared instructional strategies aimed at improving implementation of wikis for collaborative activities.

6.1.5
Augmented reality in poster presentations.

As presented in Section 5.7, posters are often incorporated as assessment strategies. Posters allow students to collate and visually present any element of a course, i.e. literature review topics, practical reports, research project findings etc. However, unless the students are beside the poster, the level of true understanding or comprehension of the information is difficult to assess. Augmented reality (AR) can begin to address this limitation, adding a new dimension to poster submissions. AR allows combines real entities with virtual ones making them interact in real time (Azuma & Azuma, 1997). For example, virtual objects can be superimposed upon their real environment (Bree, 2017a; Lukosch, Billinghurst, Alem, & Kiyokawa, 2015). In a format, similar to the use of QR barcodes, the students can embed videos in to their submission that the educator can view to obtain further information on elements of the poster, for example the student(s) could talk through the results presented, highlighting the key findings. AR technology has been implemented to assist clinical skills teaching in practical sessions, as well as anatomical variations in medical settings (Garrett, Jackson, & Wilson, 2015; Hong, Bezard, Lozanoff, Labrash, & Lozanoff, 2015). While focusing here on the use of augmented reality with regard to poster presentations, this functionality can be easily transferred to any element of education, such as a lecture handout or practical manual (Bree, 2017a), amongst others.

6.1.6
Social media in a practical environment

The influence of social networking in recent years has been wind-ranging; often now found moving from social to professional settings (Simon, 2001; Veletsianos, 2012). Undergraduates have been shown to interact with social networking sites more than graduates and faculty (Jacquemin, Smelser, & Bernot, 2014). Online spaces such as Facebook, Instagram, Snapchat and Twitter have become ‘places’ many visit numerous times per day. With regard to implementation in a practical setting, twitter use may allow the asking of questions by the practical participant that could provide clarification on a particular issue. The use of a hashtag (#) label to generate and follow a conversation (Rehm & Notten, 2016) in a practical would allow all participants to engage with, participate and follow the discussion points during the session – this might be ideal for large group number sessions. Each twitter post is limited to 280 characters, so this will promote concise questioning and answering.

6.1.7
Assessing OSCE’s digitally

As mentioned in Section 1.1, the OSCE is used in many nursing, midwifery, medical and veterinary programmes as the primary assessment tool. Each OSCE performance is normally broken down in to a set of competencies or items with each one evaluated (Walters & Adams, 2002). It is regularly scored using a paper system containing checklists and rating scales, referred to as criterion rating tools (Rushforth, 2007). While the OSCE practice remains cemented in education, digital approaches to assessment have been developed by companies such as eOSCE (http://eosce.ch/). Benefits of moving to a digital assessment tool include quicker evaluation times and a reduction in missing, or erroneous, data.

6.2
VIDEO TECHNOLOGY BEFORE, DURING & AFTER PRACTICAL SESSIONS

One element of technology enhanced learning that has become quite widespread in both use by educators, and appreciation by students, involves video-based learning resources. Videos, simulations or animations are often incorporated in classroom lectures (and circulated to students allowing re-watching from home) to improve lecture material communication, facilitating understanding of topics/techniques, and also to assist remote learners in blended/distance courses. In each case, they are used to assist students seeing processes in action and develop their learning, at their own pace (Chan, 2010; Whatley & Ahmad, 2007). However, they also possess significant value for use in practical skill development.

6.2.1
Lights, camera, action

In general, as a visual species we can rapidly assimilate information shown to us via visual media (Ouimet & Rusczek, 2014), while with advances in smartphone development, students now possess the capability to create their own video material with minimal training or guidance required. Forbes and colleagues (2016) identify video as an approach that can enhance the quality of clinical skills education with Kelly, Lyng, McGrath and Cannon (2009) recommending that video would be best integrated to complement (rather than replace) face-to-face lecturer demonstrations.

There have been recent reports of students generating post-lab video-based practical reports (vs. paper submissions) (Hazzard, 2014; Olivas, 2013). These reports outline student views with some showing preference for each reporting format. While screencasts came with numerous favourable comments from students, there were comments regarding written reports that must not be completely ignored; these stated that written reports require more thought, paint a more accurate picture of the experimental process, are clear and concise while providing more opportunities to go into depth (Hazzard, 2014). The same report makes reference to a particular project focused on academic writing, whereby students can submit a team screencast, to facilitate skill development (group work, creativity, technology use, data recording/presentation, interpretation etc.), but also request each student submit a complementary practical report. With regard to video assessments of OSCEs, Framp and colleagues (2015) briefly describe their trial of video assessment with nursing and midwifery students. Here, students worked in groups to submit recorded videos of clinical skills being demonstrated for assessment. A reflection piece was included in their submission. Students reported enjoying this assessment process, being able to self-correct during completion of the assessment, and add a verbal reflection at the end of the piece if they had omitted a certain aspect of the clinical skill. Educators identified resource savings, with less time needed for grading. The authors hope to trial this assessment strategy across other nursing programmes at their institution (University of The Sunshine Coast, Queensland).

In Section 5.2, the importance of pre-practical activities was highlighted, with this representing an area in which video can play a significant role. Watching relevant videos prior to a practical or class allows educators to have time to engage in richer discussions during class/contact hours (Bree, 2017b; Chua Hean, Oh, Wee, & Tan, 2015). Research into motor skill development has shown that in order for one to commence a certain task, one needs to know the optimum end result (Schmidt & Wrisberg, 2004) and in the development of competencies, video can assist with this goal (K. Dunne, Brereton, Bree, & Dallat, 2015). Digital exemplars of high-quality work can also be of benefit to learners in a practical environment (Kavanagh, 2017).

Dunne et al. (2015) showed the use of pre-practical videos helped to alleviate concerns around large class sizes and restricted opportunities in practical sessions for practice and one-to-one tuition. In this study, one student commented

'[It's] difficult to visualise how skills are carried out when they are just written down. Seeing a skill being carried out helps to clarify things'

(Dunne et al., 2015, p25814). Coffman (2012) also commented on student preparation before nursing practicals consisting of both reading assigned textbook sections and viewing videos of the skills procedure. From a science point of view, making customised instructional videos available prior to practical sessions has been previously reported (J. Dunne & Ryan, 2012). The authors identified that students engaged more with video material prior to the laboratory for preparation, rather than with the practical manual itself, while the students also performed MCQ quizzes to test their understanding before entering the laboratory (the quizzes were automatically graded with instant feedback provided). Others comment on similar approaches, however mention using the initial stages of the laboratory session for a brief Question and Answer session on the video resources provided prior to the laboratory (Bree, 2017b; Meade, Raighne, Gregan, Naydenova, & Pedreschi, 2015; Zwickl et al., 2013).

While the use of video pre- and post-practical has been outlined above, the practical itself can also include video opportunities for both educator and student. For example, live streaming of certain non-hands-on practical sessions (or demonstrations) can assist distance learners, with software such as 'Adobe Connect', 'BigBlueButton' as well as the 'Periscope' and 'Meerkat' apps facilitating this concept. Phillips, Robertson, Batzli, Harris and Miller (2008) incorporated video recording of student presentations for evaluation by independent examiners; who reviewed the appropriate use of concepts, correct data analysis, development of a logical and appropriate scientific argument supporting the practical's outcome. Learners meanwhile, can use smartphones to record high-quality video of a technique, clinical skill or experimental procedure in action for inclusion in their electronic lab notebook (ELN), or ePortfolio (see more on these in section 6.3 below). Verran (1998, 2009) and Brazil (2016) (personal communication), describe the development of a bank of microbiological technique videos by students, who designed, choreographed and directed the videos.

6.2.2
Virtual Labs

The abbreviation MOOC (massive open online courses) is one many educators have become fully aware of. The initial goal was to have the ability to share college lectures with as many people as possible, using an online interface. While this approach may suit certain course topics, concerns have been raised regarding practical sessions (Waldrop, 2013). Many would argue practical skills have to be acquired via a hands-on activity/performance/experience. The Open University have developed their own online version of a practical laboratory, namely OpenScience Laboratory (Open-University, 2016). Here, they promote the ability to use

virtual instruments (e.g. virtual microscopes) and provide remote access to instruments/experiments, to collect real data for analysis. There are numerous other virtual lab providers, for example 'Labster' for life science teaching and learning (Labster, 2016). They promote the advantages of virtual labs being able to perform experiments that are too expensive, time-consuming or unsafe for a learning environment while offer the integration of 'gaming' style approaches to assist in the analysis of experiments and data. While certainly having defined benefits in situations as noted above, and in particular with MOOCs or complementary blended learning approaches to standard practical sessions, there remains concerns to note. One must be aware of the lack of physical hands-on activity, the absence of live instructional guidance and mentoring, and be considerate of the impact this may have on the students' skill development. Many researchers remain concerned that a completely virtual lab is not able to completely replace time at the actual bench, handling equipment and measuring out reagents etc. (Waldrop, 2013).

6.3
ELECTRONIC APPROACHES TO PRACTICAL REPORTS, JOURNALS AND PORTFOLIOS

Detailed note-keeping has long been an essential feature for research and scientific discovery. For undergraduate students in practical sessions, observations, data or experimental results are typically recorded or reported in paper format. The dawn of the digital era has brought changes to this traditional approach, for example video practical reports as earlier described and also the use of electronic lab notebooks (ELNs) - a change that some refer to as revolutionary, and others as evolutionary (Bird, Willoughby, & Frey, 2013; Kihlén & Waligorski, 2003).

6.3.1
Electronic Lab Notebooks

The ELN brings with it numerous advantages such as workflow, user-defined templates, remote access, data management, sharing of data, data searching facility, reduction of duplication, security, and back-up possibilities (Johnston, Kant, Gysbers, Hancock, & Denyer, 2014; Kihlén & Waligorski, 2003; Machina & Wild, 2013). Essential metadata (data about data) can also be recorded in ELNs, for example outlining experimental parameters, recording reagent information, user identification or deviations to certain procedures (Nussbeck et al., 2014). ELNs also allow the generation of templates to assist in data entry and implementing efficient workflow processes – laboratory members will not engage with ELNs if workflow becomes time-consuming or tedious. Utilising user-generated templates can ensure that reporting can have a structured framework (Hall & Vardar-Ulu, 2014). While ELNs are becoming state of the art in the bio/pharmaceutical industry (an example of such described in Kihlén (2005)), academic life-science labs are still remaining loyal to the standard approaches with digital recording-keeping quite controversial in some academic circles (Nussbeck et al., 2014; Walsh & Cho, 2013). The technology must mirror a researcher's normal workflow process and be at least as easy as a paper notebook, or else the uptake could remain low (Drake, 2007; Rees, Langley, Chiu, & Ludtke, 2013). Academic institutions should embrace the advantage that ELNs can provide an ideal approach to maintain grant-funded data, prevent data loss and improve transparency of publicly funded research (Nature, 2007).

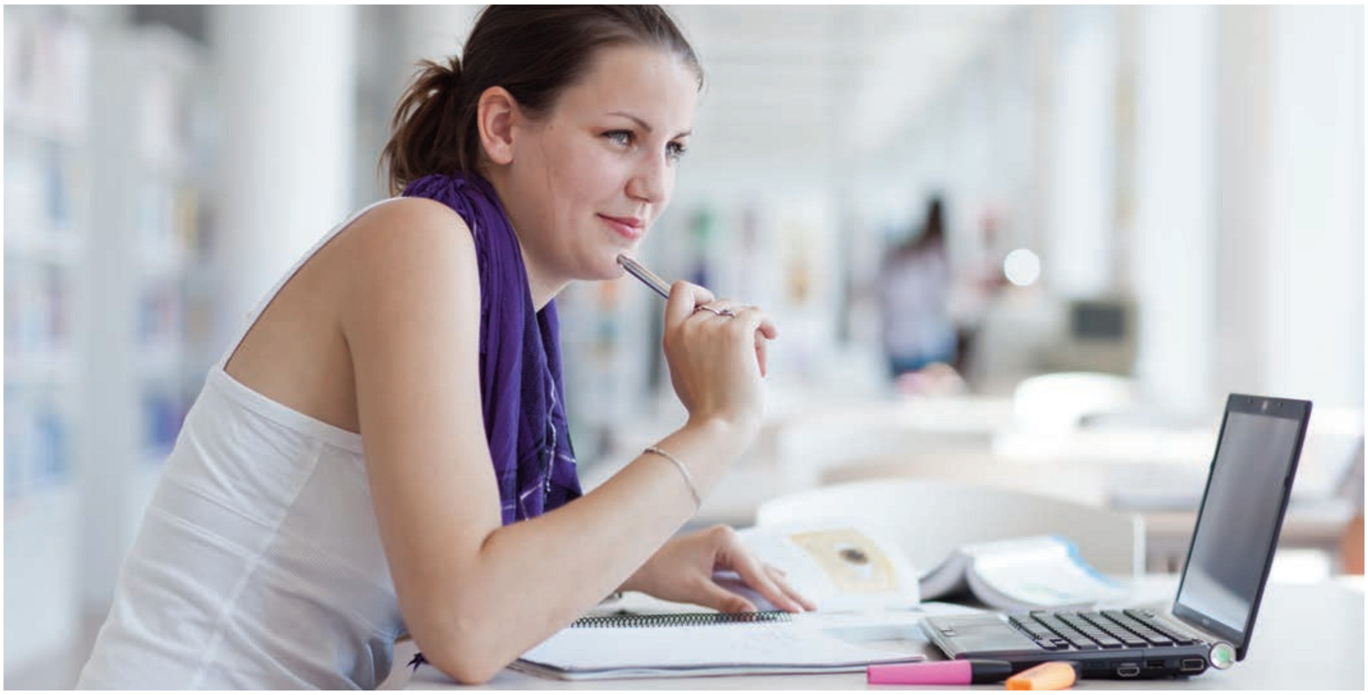
ELNs have now become a business entity, with numerous options available (a 2011 analysis presented 30 separate vendors (Rubacha, Rattan, & Hosselet, 2011)). However, they often come with a subscription cost and hence some educators have developed more 'home grown' versions (Johnston et al., 2014). For example, Walsh and Cho (2013) present 'Evernote' (https://evernote.com/) as an alternative ELN, possessing capabilities to search and share data being important advances. Evernote also allows sketches to be drawn on iPads and recorded, screenshots to be captured and all stored in its space-less storage. In a similar fashion, programmes such as Microsoft OneNote could also be adapted for use as an ELN, or used as electronic data notebooks or even reflective learning journals. Its use is also not limited to the science field or reporting, being transferable to any field. These electronic data entry approaches can be used for journaling, reflective practice, data entry, practical reporting, portfolio development and research projects cementing their position in the technology field.

6.3.2
ePortfolios

As described above, ELNs can be used directly as digital notebooks. However, there is another beneficial feature often associated with certain ELN technology platforms – the generation of an ePortfolio from its content. This represents a service also provided by several other VLE providers (e.g. integrating Mahara https://mahara.org/) to certain institutional Moodle pages. ePortfolios allow evidence of learning, accomplishments and long term personal and professional development to be collected and reviewed. Originally, they were referred to as a promising *'way of the future'* in midwifery practice, with students reporting its use as *'simple, streamlined and safe'* (Pincombe, McKellar, Weise, Grinter, & Beresford, 2010, p. 94). However, the students also emphasised the need for the platform to be student-centred, user-friendly and have a structured, discipline specific design in addition to being safe to use and regularly backed-up to prevent data loss. In this case, the ePortfolio acted as a link between experiences gained in clinical practice/ placements and college teaching. A separate report presented the use of ePortfolios to assist nursing students (Karsten, 2012). Here, the author outlines how ePortfolios represent an ideal vehicle for nursing students to present a collection of their work, demonstrate clinical competence and allow an opportunity for reflection - again helping to link clinical experience with classroom teaching. Buyarski and colleagues (2015) outline the need for a conceptual model assigned to focus, provide guidance and clarity on the intended goals of the ePortfolio implementation. In addition to public web profiles, ePortfolios represent another avenue for displaying digital badges earned by the student, highlighting progress or mastery, competencies acquired or overall achievements (Kehoe & Goudzwaard, 2015). Overall, the ePortfolio represents a way to capture and document skill development, outcomes and evidence of learning across a range of contexts. They provide the student with an excellent approach to capture their engagement online and display their employability after college – ultimately facilitating the transformation of *'learners into professionals'* (Faulkner, Mahfuzul Aziz, Waye, & Smith, 2013). One negative to implementing ePortfolios can often be associated costs – however one should not ignore the possibilities of students using software such as Microsoft OneNote as an alternative, or even setting up a free Tumblr Blog page (https://www.tumblr.com/) could introduce the ePortfolio concept with a group (other free options available through weebly and wordpress).

6.3.3 Digital badges

To date, a learner's accomplishments in education have been associated with the award of a degree, with the addition of qualification letters after one's name. This remains standard practice. However, in more recent times, when students are preparing curriculum vitae for employment, it is important to prominently display and highlight the skills acquired during their degrees. The dawn of the digital era, and online career profiles (available on sites such as https://www.linkedin.com/), students need a recognisable avenue to display accreditation for the acquisition of skills, accomplishments, quality or interest. Digital badges represent symbols of achievement, and digital badges are online records of these achievements (Hensiek et al., 2016; Parker, 2015). Badges, or micro-credentials, can promote continued engagement, help identify progress along with motivating and supporting the acquisition of skills (Gibson, Ostashewski, Flintoff, Grant, & Knight, 2013). Metadata associated with each digital badge can provide further information on the form of skill acquired, with the reputable institution accrediting the badge etc. The introduction of digital badges can add more weight to ePortfolios, LinkedIn accounts, personal webpages. Mozilla's Open Badges initiative (http://openbadges.org/) has driven much of the global conversation on this innovation; *'Earn, Issue, Display'* is mentioned on their homepage and summarises the role of these visual, online symbols of achievement. Towns, Harwood,



Robertshaw, Fish and O'Shea (2015) employed digital badges with first year undergraduate students in science laboratory sessions to reward the acquisition of pipetting skills. They report their use '*significantly and positively impacted classroom practices' (*2015, p. 2043), improving pipetting skills and experience, knowledge and confidence. Used in combination with other technology driven interventions, or assessment strategies, validated digital badges can have a significant impact in the practical, and other, learning environments.

6.3.4
Providing feedback on assessments – the digital options

While this review has already outlined the critical role of feedback in both the assessment and education fields (see Section 3, 5.4), advances in technology have created numerous avenues for distribution of, and engagement with, timely feedback (see Table 8). However, while technology can assist in the provision of feedback, one must be aware of the emotive effect the feedback format can have on a student receiving said feedback (Henderson & Phillips, 2015; Voelkel & Mello, 2014; Winstone & Nash, 2016; Winstone et al., 2017), in addition to the need for a feedback dialogue being ever-present (as outlined in Section 5.4).

Technology Software	Overview
Audacity (http://www.audacityteam.org/)	Provides free recording and editing facility for audio feedback to be prepared. The file created can be sent to a student via e mail, VLE or as a podcast.
Screencast-o-matic (https://screencast-o-matic.com/home)	Allows screencast recording to be performed (Free version allows a maximum of 15 minutes to be recorded). This can allow review and feedback generation of digital submissions to be recorded and subsequently sent to students. This could be ideal for providing feedback on ePortfolio submissions.
Moodle/Blackboard/other VLEs (https://moodle.com/ http://uki.blackboard.com/)	Many VLEs offer feedback options when grading submissions of work.
ELNs (for example: http://www.labarchives.com/)	Many of the ELNs available allow review and comments/feedback/annotations to be provided directly through the software.
Turnitin (http://turnitin.com/)	Often considered solely a plagiarism checker generating originality reports, Turnitin has expanded it's remit to allow grading of submissions with feedback options.
MyProgress (http://www.myprogressapp.com/)	A smartphone/tablet app that can be used for recording and providing feedback in observational assessments.
PDF Annotators (e.g. Apps such as Goodnote, PDFReader Pro etc.)	Allows annotations to be made on submitted pieces of work and directly sent via e mail to student.

Table 7: An overview of digital approaches for feedback distribution and engagement. A brief outline of each is provided. Adapted from recommendations outlined by Y1Feedback (2016).

This section has outlined numerous approaches on how technology can be used to enable, or support, assessment strategies in the practical environment. As educators, we have the opportunity to integrate these tools in order to enrich teaching and benefit the learning experience of the student in the practical environment. Building and improving digital capacity and digital literacy has the potential to assist in supporting and enriching vibrant learning strategies in our Higher Education institutions, as per the National Forum's digital roadmap (NFETL, 2015).

7.0 CONCLUSION & RECOMMENDATIONS

In science and health, the practical plays a critical role in the development and training of students, empowering them with technical, practical, clinical and soft skills. It is essential educators embrace the role and capabilities of practical sessions, and not consider them as a minor add-on to a modular course. This review has outlined some of the concerns with the practical session in practice, highlighting areas currently in use that can be enhanced and also demonstrating how technology can be implemented to support and enable assessment. While many educators, and students, are realising the potential brought by introducing digital skills and literacy in their classrooms and practical sessions, a report from the European Commission (EU Commission, 2014) recommends further building on this strong existing base of digital education. For example, it recommends that metrics be recorded to measure extent of online/blended/open education and that a vision for change is needed to be implemented via national strategies, one which the National Forum in Ireland is promoting with their digital skills roadmap.

In a practical, the format of the session and the associated assessment strategies are critical elements for educators to design and implement. However, as pointed out by Bennett and colleagues (S. W. Bennett et al., 2009), in attempts to improve assessment strategies, there can be a concern of the assessment process becoming a time burden for both staff and students, and the fact that not every element may need to be assessed is worth considering at the design stage. In this review, numerous concepts and resources have been presented to assist educators in both the format, and the assessment, of practical sessions, helping to create a vibrant learning environment with a focus on digital approaches. The review itself proposes five recommendation areas:

RECOMMENDATION AREAS

1. **Design, Format and Practical Learning Environment (Table 9)**
2. **Pre-practical Resources (Table 10)**
3. **Assessment & Feedback (Table 11)**
4. **Self-Assessment & Reflection (Table 12)**
5. **Building Digital Capacity and Literacy (Table 13)**

Recommendation Area 1: Design, Format and Practical Learning Environment	**Relevant Section of Review for further info / citations**
Educators must consider the importance of the learning environment being created. Implementing particular styles can have a dramatic effect on the learning experience of the student, in addition to metacognitive and communication skill development	1.1, 1.2 & 5.1
Design investigations with 'minds on as well as hands on'	1.2
Ensure the 'purpose' of the practical is clear	1.2.1
Transition the philosophy of learning outcomes or objectives to individual practical sessions, in addition to the associated module or programme.	5.1
Generate a powerful learning environment for practical sessions; a more active, student-oriented approach has reported significant deeper approaches to learning.	1.1 & 5.1
The format and learning strategies for the practical session must be considered; consider solving 'real life' problems.	5.1
Elements of inquiry based learning should be involved in some capacity; Real life/Research questions being posed. Consider deductive for some labs then move to inductive labs. Develop independence, responsibility, hands-on approaches and encourage independent thinking in students.	1.2 and 5.1
Move away from the traditional, structured, memorisation themed instruction base to an experience learning base.	5.1
Being aware of how practical sessions are planned and structured can have a lasting impact.	5.1
Consider the goals of the practical session - what specific practical skills are to be assessed? Best way to assess them?	5.8
Consider reviewing the format of the practical manual, reduce non-relevant information, provide more inquiry based approaches.	5.9
Provide time for dialogue, troubleshooting, asking questions, reflection, feedback uptake, suggest hypothesis, design investigations, develop self-confidence	1.2
Practical sessions should promote further social interactions	5.1

Table 9: Recommendation Area 1: Design, Format and Practical Learning Environment.

Recommendation Area 2: Pre-practical Resources	Relevant Section of Review for further info / citations
Consider assisting 1st years with no prior knowledge of subject area; utilise online introductory eResources and quizzes prior to lectures/practicals to reduce cognitive load and facilitate in-class work. Pre-practical quizzes can also identify conceptual areas needing attention/clarity before commencement of the session.	5.2
Pre-lecture concept needs to be transferred to the practical curricula; represents a positive and engaging approach to motivate and focus students - stimulates learning and understanding overall.	5.2

Table 10: Recommendation Area 2: Pre-practical Resources

Recommendation Area 3: Assessment & Feedback	Relevant Section of Review for further info / citations
Ensure assessment options and interventions are all considered and implemented correctly. Review if every activity needs to be assessed. Students can assign less value to approaches, believing they do not warrant attention if less assessment is given to that approach (e.g. practical skill development).	2 & 4
Ensure assessment practices motivate and challenge students.	2
Consider use of an OSCE like performance assessment in the science laboratory.	5.8
Review the role of the practical report, the need for it after every session and standardisation across modules in a programme.	4
Embrace benefits of the practical report, however consider restructuring its format to make it more effective at the conceptual understanding and logical thinking levels (e.g. the SWH method).	5.3
Consider advocating rubrics not solely as scoring tools but as complete teaching resources that aid the development of assessment literacies.	5.6
If students are presenting their findings in an oral presentation, introduce a self-marking strategy after watching a video of the presentation (develop reflection, self-assessment and feed-forward).	5.7
Move away from MCQ based quizzes and embrace approaches to measure what students can do with the knowledge gained, rather than examine recalling information. Develop free response and open ended questions from higher levels of Bloom's taxonomy.	5.9
Develop/maintain focus on developing relevant practical/clinical skill sets	1.1, 4 and 5.8

Recommendation Area 3: Assessment & Feedback	Relevant Section of Review for further info / citations
Using facilitator-focused feedback is more centred on the learning process and development of metacognitive skills in the student (vs. content focused feedback which provides further knowledge in feedback).	3
Consider incremental grading system to encourage better feedback uptake	5.4
Educators must introduce a clear-communication dialogue on feedback with students; provide guidance/advice on understanding and using feedback.	3 & 5.4
Implement a feedback review time-slot in a practical session, followed by open discussion.	3 & 5.4
Consider use of posters as assessment tool (in combination with augmented reality technology).	5.7
Improve standardisation of assessment and feedback criteria and approaches across different modules.	4

Table 11: Recommendation Area 3: Assessment & Feedback

Recommendation Area 4: Self-assessment and Reflection	Relevant Section of Review for further info / citations
Implement self-assessment strategies and encourage students to reflect on their work, effort, feelings and accomplishments	5.5 & 5.7
Consider training through practice on both self- and peer-assessment before their implementation	5.5
Ensure students develop an ability to recognise and appreciate hard work, helping them evaluate the quality of their own submissions and efforts during production	3, 5.4, 5.6

Table 12: Recommendation Area 4: Self-assessment and Reflection

Recommendation Area 5: Building digital capacity & literacy	Relevant Section of Review for further info / citations
Embrace digital capacity development to support and enrich vibrant learning strategies	6
Consider virtual labs to complement hands-on practical sessions	6.2.2
Utilise ELNs to collect searchable data online, develop student portfolios as well as prevent data loss.	6.3.1
Combine digital badges with ePortfolio/ELN use	6.3.2 and 6.3.3
Consider ELN and ePortfolio implementation across programmes (vs modules)	6.3
Engage learners with real time quiz and polling apps/software	6.1.1
Consider digital approaches to feedback	6.3.4

Table 13: Recommendation Area 5: Building digital capacity and Literacy

In addition to the acquisition of formal qualifications, student employability has begun to encompass the skills developed and mastered during their time in higher education. The practical component represents a significant place of learning, a powerful learning environment with the capacity to develop skills on several levels. As discussed in this report, the format and assessment strategies are critical for success, and require considerable attention. Harnessing the power and potential of technology to enhance digital capacity and support learning in the practical session is an aspect that needs to be embraced by both educators and students. As this review mentioned in its opening line, those in a teaching capacity need to focus on the quality of their students' learning and understanding, aiming to empower active learners to develop higher order skills to assist them in both their careers and lives after college.

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9.0
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TEAM

Technology Enhanced Assessment Methods in Science & Health Practical Settings.

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