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A Short Review of Online Learning Assessment Strategies

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ABSTRACT

The COVID-19 pandemic has caused a paradigm shift in how teachers, instructors and students approach teaching and learning, especially concerning the migration to online learning environments. One of the most challenging aspects of adapting to online/virtual education is evaluating students' knowledge acquisition through learning assessments. The lack of face-to-face proctoring renders many of the traditional paper-based assessment techniques impractical, especially in the context of an engineering education that is heavily focused on applied learning. Since virtual education now represents an important evolution in education, it is pertinent for educators to familiarise themselves with the new possibilities of assessment methods in a virtual setting, and to design tailored assessment strategies for individual courses. This article reviews and summarises commonly employed virtual assessment methods that are applicable to most engineering educational situations, such as open-book exams, online quizzes, or peer assessments. The paper also discusses some concerns that may arise in implementing these methods. Additionally, there is a particular focus on qualitatively-graded ePortfolios as a unique pedagogical tool in the virtual classroom due to their role as both a repository for storing learning artefacts and a vehicle for advancing students' learning experience.

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1. INTRODUCTION

With the disruption caused by the SARS-CoVid-2 pandemic, teachers and instructors around the globe have migrated to online-synchronous (real-time streaming of lectures conducted by an instructor) and/or online-asynchronous (pre-recorded streaming of lectures without a live instructor) education. It has taken a substantial amount of effort for both students and instructors to become accustomed to the new virtual setting. The advantages of online teaching are evident: 1) it is more approachable for students who have trouble accessing their university campus (Lei & Gupta, 2010); and 2) it is more cost efficient than in-person teaching, apart from the cost of creating or maintaining learning management systems and assessment software (Abubakar & Adeshola, 2019). These two reasons alone will ensure that many programmes and courses will be offered either entirely or at least partially in an online format.

However, the downside of online education must also be acknowledged; for example, the lack of a social and campus environment that enables students to experience a typical post-secondary education (Barr & Johnson, 2021; Dumford & Miller, 2018; Moise, Diaconu, Negescu, & Gombos, 2021; Muhammad & Srinivasan, 2021). From an instructor's perspective, the most challenging aspect of online education is the course assessment component (Hewson, 2012; Kallia, 2017; Khan & Khan, 2019). Due to the lack of face-to-face proctoring, many traditional paper-based assessments designed for testing the basic concepts and knowledge of courses become impractical. This is particularly true for various engineering courses, in which the ability to apply and utilise knowledge is the ultimate objective of the learning process (Rassudov & Korunets, 2022).

A small number of studies (Hewson, 2012; Page & Cherry, 2018; Spivey & McMillan, 2014; Tsai, 2016) have shown that a well-designed assessment strategy can minimise the difference in students' academic scores between online and in-person assessments. It is pertinent for educators to familiarise themselves with the new possibilities of assessment methods in the online setting, and to design tailored assessment strategies for each particular course. However, there is a gap in the literature related to studies that specifically focus on and describe methods for evaluating engineering students' learning outcomes in a virtual setting. Therefore, the purpose of this article is to review common assessment methods for online settings and to discuss the concerns

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that may arise from implementing them. These online assessment methods include open-book exams, online quizzes, peer assessments, and ePortfolios. There is a particular focus on *qualitatively graded ePortfolios* as a unique pedagogical tool in the virtual classroom due to their dual role as a repository for storing learning artefacts and as a vehicle for enhancing learning outcomes.

2. METHODOLOGY

The paper is a narrative literature review utilising secondary research sources. The primary research objective is to summarise the common forms of online learning assessment methods in an engineering context. The secondary research objective focuses on e-portfolios as a unique and innovative way to facilitate active learning in the online educational environment. Since both topics are broad and have been conceptualised differently by various researchers in different disciplines, a full systematic review process was not feasible since it would have been impossible to review every article relevant to the topic. Instead, we performed a literary database search in three phases to identify and summarise common themes in each phase. The first phase involved collating and screening literature that reviews virtual and in-person assessment methods in a technical STEM context, such as Kallie (2017). The inclusion criteria for this phase were relatively minimal, primarily articles with 'assessment' or 'assessment method' and 'engineering' or 'computer science' in the title and abstract. Preference was given to articles published after 2010. Initial screening is made by reading the title and abstract of the article to ascertain if it met the inclusion criteria, followed by a review of the full text to make the final selection of sources in this phase. This general inquiry allowed us to develop a preliminary list of virtual assessment methods that may apply to technical courses in engineering education, while excluding other methods. For example, in the area of computer science, coding assignments are technical assessments that can take place virtually, while an in-person laboratory experiments are not feasible in an online environment. The second phase involved a deeper investigation into the common assessment methods found in phase 1 and a summary of their implementation in the online learning environment, along with the associated risks. The inclusion criteria in this phase pertained to each assessment method in the list, such as it being listed in the title and abstract of an article. A similar selection process was used in this phase as that in phase 1. The final phase involved a literature search of pedagogical frameworks that can be applied to each assessment method in order to help measure their utility in facilitating active learning and knowledge acquisition, as well as other factors impacting educational experiences. Such frameworks and inclusionary criteria included 'Problem-Based Learning' and 'Gradeless Learning'. The same selection process was used in this phase as in the other two. After each phase, thematic analysis of the articles was conducted to identify common themes and issues, as well as theoretical frameworks that were pertinent to the two research objectives (Figure 1). The findings of these analyses are presented in the following paragraphs.

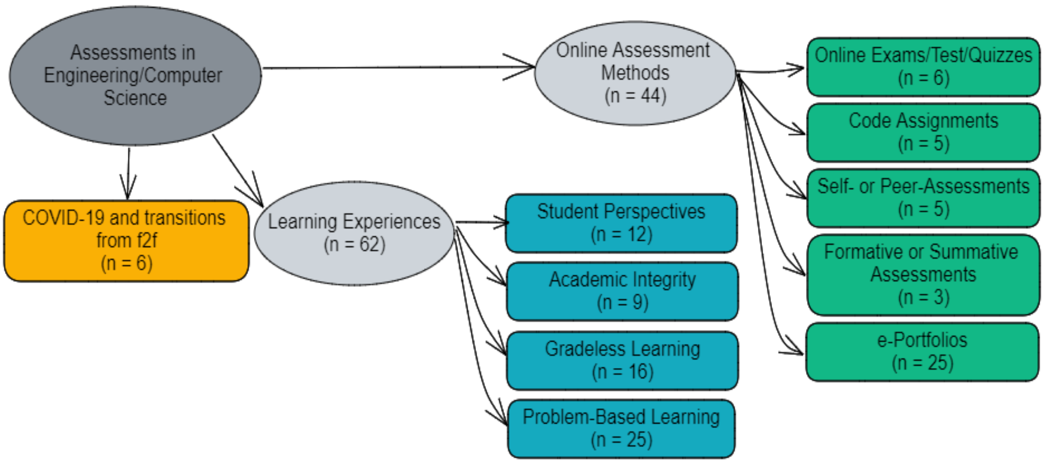

Fig 1. Flowchart summarising the common themes from the literature studied, such as feasible virtual assessment methods (green), transitions to online learning from face-to-face (f2f) (orange), and pedagogical frameworks or other factors that affect students' learning experiences (blue). The number of articles within each domain is denoted by *n*.

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3. VIRTUAL ASSESSMENTS

Open Book Exams

As the pandemic forced educators to shift their focus towards remote learning, new obstacles arose in relation to examinations. Physical proctoring was severely restricted and preventing students from consulting external sources was almost impossible. In such circumstances, open book exams are popular alternatives that can be utilised synchronously (e.g., within an exam time) and asynchronously (e.g., take-home tests). In this method, students are usually allowed to have access to their notes and the internet to mine information to complete the exam (Fask, Englander, & Wang, 2014; Hylton, Levy, & Dringus, 2016).

However, the challenge for instructors is to design appropriate assessments that can assess higher-level cognitive processes (e.g., application, analysis, evaluation, creation) and mastery of course concepts (Boitshwarelo, Reedy, & Billany, 2017; van de Heyde & Siebrits, 2019), minimising the possibility of students simply looking up the answers online. In other words, assessments should not consist of questions that simply seek information. Instead, they should require students to apply concepts learnt to solve higher-order problems. As pointed out by Russell and Shepherd (2010), designing and implementing such assessment schemes is fairly time-consuming. Furthermore, in such pursuits, instructors often develop assessments with fewer but more involved questions (Myyry & Joutsenvirta, 2015), which may not allow a comprehensive assessment of students' knowledge of the subject compared to a traditional closed-book exam. However, such tests on basic concepts can be achieved through the use of a collection of short quizzes administered periodically during the course. During the grading stage, it is helpful to adopt anti-plagiarism software if the exam is intended to be completed independently (as opposed to teamwork). This can be helpful for paper-based exams that are marked by scanning the answers. Another possibility is to develop assessments that focus on research, commentaries, and reflection as the outcome of the final exam. Such assessment practices will help put the focus on learning and minimise issues of plagiarism.

Automated Assessment Tools

For programming courses in engineering, various industrial-level tools are available that provide integrated environments combining language editor and automated assessment; for example, LeetCode, HackerRank, and CodeSumit. Educational institutions have either collaborated with these industry platforms or developed their own automated assessment environments for programming courses (Kallia, 2017; Centea & Srinivasan, 2021; Boe et al., 2013; Bryce et al., 2013). In general, these tools are capable of auto-formatting, detecting syntax errors, and providing runtime feedback on warnings and exceptions. In addition to employing these for assessments, students could also use them for self-study. For instance, in the programming courses taught at the W Booth School of Engineering Practice and Technology at McMaster University, training is provided to graduate students as seasoned code developers on such integrated development environments during the classroom instruction. The prompt feedback through the debugging environment helps students understand their mistakes (McMillan & Hearn, 2008) and actively explore ways to fix bugs. In other words, using appropriate active learning and intervention strategies (Gaganpreet Sidhu & Srinivasan, 2015, 2018; Srinivasan & Centea, 2015, 2018; Srinivasan & Sidhu, 2014), we can significantly enhance student learning, preparing them adequately for assessments using such integrated development environments.

Online Quizzes

Even before the pandemic, in-class quizzes using modern technology such as clickers had been adopted by institutions around the world. Recent migration to online teaching has made web-based quiz systems widely available for instructors (Lei & Gupta, 2010). Existing video and telecom platforms (e.g., Zoom, H5P, and Camtasia) allow instructors to embed interactive quizzes into their online lecture sessions. Such quizzes are similar to the clicker questions administered during in-person lectures and can help reduce mind wandering, improving learning in online lectures (Szpunar, Khan, & Schacter, 2013).

In general, quizzes are an efficient way of applying the spacing and interleaving techniques to promote retrieval and retention (Roediger & Butler, 2011). A common strategy is to develop frequent and low-stake

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quizzes that help maintain students' engagement throughout courses, especially when they are administered regularly (Sweeney et al., 2017). Most web-based quiz systems allow instructors to set the availability window and time limit of each quiz, encouraging students to participate regularly. Assigning a certain percentage of course grades to the completion of quizzes ensures that students make an effort to do well in this assessment component. Short quizzes are ideal for testing basic concepts and knowledge of the course topics (Ardid, Gómez-Tejedor, Meseguer-Dueñas, Riera, & Vidaurre, 2015; Shuhidan, Hamilton, & D'Souza, 2010). For example, in programming courses, questions based on finding and fixing errors, or writing short syntax or program statements help reinforce the syntax and structure of programming languages. They complement more comprehensive exams that focus on application development and problem-solving. Ahmadzadeh et al. (2005) demonstrated a proportional relationship between students' debugging skills and their ability to write programs. Similarly, Murphy et al. (Murphy, Fitzgerald, Lister, & McCauley, 2012) recommend training students by honing their ability to read and understand code through debugging tasks.

It should be noted that there is no universal online quiz or testing system that is applicable to all courses. Therefore, it is useful to prepare sample tests and mock exams for students, which help to familiarise themselves with the online testing environment and prepare them for quizzes and formal exams (Khan & Khan, 2019). Finally, another tactic that instructors can use to discourage plagiarism and cheating is to increase the number of questions in the quiz pool and randomise their order for each quiz (Boitshwarelo et al., 2017). With a restriction on the duration of the quiz, and the introduction of two-level randomisation, i.e., random selection within a pool coupled with a random selection of pools, collaboration can be minimised. On the other hand, if the true objective is learning and there is adequate maturity in the students, then we could encourage collaborative testing of the quizzes, which will help enhance learning. This approach is often useful if the class comprises adult learners who are taking courses to help advance their careers. Such students are often more driven to understand the essence of the subject and are more committed to learning than securing a grade on an assessment (Gaganpreet Sidhu & Srinivasan, 2022a).

Assignments and Projects

Given the limited time and number of questions during an open-book exam or quiz, it is important for instructors to regularly design more comprehensive assignments and projects to consolidate students' learning through problem-solving. This can be achieved through problem-based learning (PBL) pedagogy, which is part of the larger group of inquiry-based learning pedagogical frameworks (Bogoslowski, Geng, Gao, Rajabzadeh, & Srinivasan, 2021; Centea & Srinivasan, 2021; Geng, Srinivasan, Gao, Bogoslowski, & Rajabzadeh, 2022; Rajabzadeh, Mehrtash, & Srinivasan, 2022; Srinivasan & Centea, 2021). In this type of pedagogy, learners apply the concepts and skills to solve problems derived from real-world situations. With an appropriately designed problem, PBL can be highly engaging for students and more representative of authentic learning processes (Centea & Srinivasan, 2017, 2019; Muhammad & Srinivasan, 2020a; G. Sidhu, Srinivasan, & Centea, 2017; Srinivasan, Rajabzadeh, & Centea, 2020; Woods, 1996). Early studies of PBL have already demonstrated the significant increase in students' mastery and perception of course subjects (Mitchell & Delaney, 2004).

For engineering courses focused on programming languages, technical design, and engineering applications, PBL is widely applicable due to the practical nature of such courses. While the lectures mostly provide isolated and content-centered topics, projects allow students to practise syntax and algorithms in the process of solving practical problems. Often, such projects are more complex by design and are ideal for group assignments (Ellis et al., 1998; Mitchell & Delaney, 2004). They facilitate the development of critical skills in real-world settings, such as implementation skills, analytical thinking, teamwork, and leadership skills (Anazifa & Djukri, 2017; Birgili, 2015; Centea & Srinivasan, 2017; Hoidn & Kärkkäinen, 2014; Rajabzadeh et al., 2022; Warnock & Mohammadi-Aragh, 2016).

Finally, as recommended by van de Heyde and Siebrits (van de Heyde & Siebrits, 2019), when designing large assignments and projects, it is often beneficial to incorporate more research papers, case studies, or additional interactive components to maintain student engagement in the project, and to promote their higher order thinking.

Peer Assessment

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The process of teaching and learning is not merely a single, ongoing interaction between the instructor and a single student, but rather a multi-lateral experience shared across the whole class. The invisible comparison and competition among peers also drive the dynamics of classroom learning. To promote interaction and collaboration between peers, educators can incorporate assessments that require students to provide comments and suggestions on a peer submission (Usher & Barak, 2018). In fact, tapping into the pedagogy of constructivist learning (Greaves, McKendry, Muhammad, & Srinivasan, 2022; Muhammad, Sidhu, & Srinivasan, 2020; Muhammad & Srinivasan, 2020b; Gaganpreet Sidhu, Srinivasan, & Muhammad, 2021; Srinivasan & Muhammad, 2020), interactive sessions involving case studies or group projects can be introduced in which student groups discuss their solutions and learn from each other (Gaganpreet Sidhu & Srinivasan, 2022b). In online settings, peer assessment can help increase the engagement and motivation of students (Kearney, Perkins, & Kennedy-Clark, 2016) by helping them recognise their strengths and weakness, thus allowing them to identify the areas for improvement (Topping, 2009). Sekendiz (2018) showed that students are usually more constructive when giving qualitative feedback to peers.

In online courses, web-based peer assessment tools can be beneficial since they are cost-efficient, flexible, and, if implemented correctly, ensure anonymity during the process (Lin, Liu, & Yuan, 2001). Without anonymity, students may provide unfair feedback clouded by their bias and personal feelings (Usher & Barak, 2018). Therefore, it is important to standardise a rubric or criteria for evaluation and provide a template for peer feedback. To promote collaboration, instructors can also establish online discussion boards using platforms such as Slack or Discord (Beebe, Vonderwell, & Boboc, 2010). With the appropriate categorisation of sub-channels to moderate different topics, instructors can seamlessly facilitate fruitful discussion among students as the course progresses.

4. E-PORTFOLIOS

An ePortfolio is an organised electronic collection of work produced throughout an individual's personal, professional, and academic career (Impedovo, Ritella, & Ligorio, 2013). Similar to their hard-copy counterparts, an ePortfolio provides an opportunity for students to demonstrate their learning journey, skills, competencies, and self-reflections, while encouraging them to make interdisciplinary connections across different course materials (Barrett, 2010; Mueller & Bair, 2018). Additionally, this digital aspect creates a multimedia environment in which students can store works that would otherwise not easily fit into a hard-copy portfolio, such as videos, graphics, websites, and audio files (Barrett, 2010; Impedovo et al., 2013). The recommended steps to creating an ePortfolio are to first collect and organise artefacts from courses, programmes of study, and individual work; critically choose the artefacts that best demonstrate one's learning development; reflect on how the selected pieces display an evolution of learning; and finally identify common points that connect the individual artefacts into a coherent summary of one's achievements (Mueller & Bair, 2018; Parkes, Dredger, & Hicks, 2013; Richards-Schuster, Ruffolo, Nicoll, Distelrath, & Galura, 2014). In recent years, the implementation of ePortfolios as a university tool has increased significantly, although they have been utilised in an educational context for decades (Hanbidge, McMillan, & Scholz, 2018; Lewis, 2017).

ePortfolio Types

An ePortfolio can be conceptualised as both a *product* and a *process* (Lewis, 2017). As a *product*, it serves as a digital storehouse for articulating one's learning outcomes and allow instructors, peers, and potential employers to assess achievements (Bryant & Chittum, 2013; Mueller & Bair, 2018; Richards-Schuster et al., 2014). These types of ePortfolios are referred to as documentation or directed portfolios and are often utilised for summative assessments in course design (Matthews-DeNatale, 2013). As a *process*, ePortfolios are a pedagogical strategy that provides a reflective space for students to learn skills in self-appraisal, self-regulation, critical thinking, and reflection while they assemble a collection of work that accurately represents their learning journey throughout the course (Mueller & Bair, 2018; Nguyen, 2013; Parkes et al., 2013; Pitts & Ruggirello, 2012). ePortfolios of this type are called development or integrated learning portfolios and are often involved in formative assessments, followed by iterative cycles of reflection, review, and feedback (Barrett & Wilkerson, 2004; Matthews-DeNatale, 2013). Finally, ePortfolios that are both a *product* and a *process* contain a selection of works that display evidence of integrated knowledge from a diverse range of sources, along with written pieces

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that reflect students' learning and professional development (Lewis, 2017). These types of ePortfolios are referred to as showcase or presentation portfolios (Barrett, 2010; Matthews-DeNatale, 2013). Unfortunately, despite its functional versatility, the ePorfolio's potential as a tool to improve students' learning outcomes is often overshadowed by its common use as simple tool for storing or presenting work (Lewis, 2017).

ePortfolios in Engineering Course Design

While the educational uses of ePorfolios is applicable to any discipline, its potential in the engineering context is noteworthy. Numerous institutions across the US have recognised the benefits of ePorfolios in tracking and transforming learning outcomes in Engineering students. For example, the engineering faculty websites of the University of Calgary in Canada and Utah State University in the United States have blog posts dedicated to encouraging students to use ePortfolios to store and track projects from their engineering courses, together with their personal reflections on these pieces of work (University of Calgary, n.d.; Utah State University, n.d.). Montana State University lists the ePortfolio as an essential component of their Engineering Communications Toolkit, while UC Berkeley runs a course entitled Ethics in Engineering, which involves the creation of ePortfolios to demonstrate students' learning experiences of the topic of ethics (Montana State University, n.d.; UC Berkeley, n.d.). For some institutions, such as Carleton University in Canada and the University of Colorado in the US, the pedagogical and career advantages of building an ePortfolio is so apparent that all students on the Engineering programme must create one in order to complete their degree (Carleton University, n.d.; University of Colorado, 2019).

Social Pedagogical Benefits

In the educational context, ePortfolios not only document learning outcomes, but also enhance them (Joyes, Gray, & Hartnell-Young, 2010). Their creation is a process that encourages students to practise skills in self-assessment, self-regulation, and critical thinking (Ivanova, 2017; Jenson, 2011). This also motivates students by allowing them to witness their learning progress throughout the duration of the course, which may lead to more engaged and active participation in classes (Gorbunovs, Kapenieks, & Grada, 2015; Impedovo et al., 2013). This enables students to gain more control over their own learning, which improves knowledge acquisition (Büyükduman & Sirin, 2010; Dominguez Garcia, Garcia Planas, Palau, & Taberna Torres, 2015). If students continue to use and upgrade their ePorfolio outside the classroom as they progress through their career, they are likely to be more flexible, integrative, and critically engaged life-long learners (Peet et al., 2011). In fact, these benefits have already been demonstrated in several groups of Engineering students (Clemmer et al., 2015; Dominguez Garcia et al., 2015; Khoo, Maor, & Schibeci, 2011).

5. DISCUSSION AND CONCERNS

Academic Integrity

With regards to digital exams and assessments, instructors are mostly worried about students being guilty of academic misconduct and dishonesty (Abubakar & Adeshola, 2019; Dermo, 2009; Mellar, Peytcheva-Forsyth, Kocdar, Karadeniz, & Yovkova, 2018). Without in-person proctoring, instructors face greater difficulty monitoring students during exams and ensuring academic integrity (Fask et al., 2014). In fact, in one survey of American students, 45% of respondents thought online education involved easier testing and less reliable grading than traditional in-person exams (Saad, Busteed, & Ogisi, 2013). The main concern of students regarding online assessments is equality and fairness (Dermo, 2009). A survey by Lee-Post and Hapke (2017) indicated that over 45% of students believed that cheating was easier in online classes, and that 30% would cheat if given an opportunity.

Plagiarism can be common among students across all academic institutions. Some cases can be inadvertent, such as not properly acknowledging sources, while others are intentionally aimed at achieving a high grade while bypassing the intended learning outcomes of the class. A potential solution to this problem is the use of modern originality-verifying software (e.g., TurnItIn), which can help detect similarities between a

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submitted assignment or test and online sources (Heckler, Rice, & Bryan, 2013; Moten, Fitterer, Brazier, Leonard, & Brown, 2013).

More direct ways of preventing cheating can be the use of existing anti-plagiarism and proctoring software during exams (e.g., Respondus) (J. Levine & Pazdernik, 2018). Other tools involve checking biometric data or keystroke dynamics for the authentication of students on written assignments and exams. However, this could be an expensive proposition for educational institutions. Furthermore, some software may pose a threat to the personal data of students. A more extensive and fundamental strategy would be to diversify the assessment methods over the course (Sato & Haegele, 2018), such as using problem-based learning, frequent quizzes, and closed-book exams focused on problem solving. Therefore, by avoiding high-stakes assessment, anxiety in students can be minimised, thus indirectly helping them to focus on the learning than the outcome of the assessment.

While the reliance on technology to prevent academic dishonesty is one approach, a more appropriate strategy would be to reinvent assessment protocols by designing assessments with the underlying assumption that students will have access to the internet. Therefore, instead of designing questions that ask for information that could be easily found on the internet, questions that ask students to apply the information, or ones that take a more philosophical tone examining the interpretation and applicability of concepts, could be employed. For example, instead of focusing on how a certain mechanism works, it might be more appropriate to focus on the feasibility of applying such a mechanism to real-life situations. Other options would be to focus on open-ended questions that require students to conceptualise and design an application. By assessing students at the higher end of Bloom’s taxonomy, unique individual solutions will be encouraged, avoiding the possibilities of academic dishonesty while allowing for the use of resources such as the internet and discussions with peers. In addition to elevated learning, these strategies will also increase curiosity and instil a sense of discovery and innovation in students, ultimately transforming them into lifelong learners.

ePortfolios

One concern with the use of ePorfolios in higher education is their correct implementation. Without focused planning and explicit communication about their purposes to students, the pedagogical benefits of ePortfolios cannot be fully enjoyed (Joyes et al., 2010; Parkes et al., 2013). Issues relating to troubleshooting technology and starting ePortfolios too late in the term become bottlenecks for instructors and students in implementing projects (Mueller & Bair, 2018). It is also essential for students to clearly understand the learning and developmental benefits of compiling an ePortfolio, as well as its nature and structure, to maintain their engagement throughout the process (Lewis, 2017; Mueller & Bair, 2018; Parkes et al., 2013).

Another risk involved with the implementation of ePortfolios is the misconception that they are simply an assessment tool with no intrinsic pedagogical value, resulting in an overemphasis on the final grade of the assessment. This issue may originate from instructor themselves, who may only view the ePortfolio as a product, which reinforces such a perspective in students (Mueller & Bair, 2018). This may result in students treating the ePortfolio as just a checklist of items that needs to be compiled to achieve the highest grade with the least amount of effort, instead of treating it as a living portal that expands their knowledge horizons and cultivates life-long learning attitudes (Mueller & Bair, 2018; Nguyen, 2013). It may also be problematic for instructors to expect students to engage in new and in-depth personal exploration and then assign a grade to it (Mueller & Bair, 2018). This is because non-academic learning outcomes that result from this exploration are, by nature, complex and subjective (Chen, Fan, & Jury, 2017). However, instructors and students are more familiar with the teaching and learning practices of graded assessments, and this familiarity becomes a source of comfort and ease in the face of fundamentally different approaches to education, such as gradeless, process-focused ePortfolios (Mueller & Bair, 2018). As a result, these groups default to the familiar learning strategy to minimise discomfort, so even ePortfolios become pigeonholed into a system that overemphasises grades. Therefore, the potential for ePortfolios to cultivate intrinsic learning behaviours is not realised.

The overemphasis on grades can also harm students' learning attitudes by fostering the motivation to chase higher grades and strengthening the fear of receiving low scores, instead of a motivation to learn that is fueled by reasons that are more instrinsic, such as discovery and skills development (Anderson, 2018; McMorran,

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Ragupathi, & Luo, 2017; Schinske & Tanner, 2014). Numerous studies indicate that if students are more likely to be motivated by grades instead of the process of learning itself, this shift in focus will undermine the goals of higher education, such as fostering the art of scholarly inquiry and developing life-long learning skills (Brilleslyper et al., 2012; Jacobs, Samarasekera, Shen, Rajendran, & Hooi, 2014; Kohn, 2011; Malam & Grundy-Warr, 2011; Pippin, 2014). Another reason why the graded system has garnered so much criticism is because of the student wellness issues and learning outcomes that result from an overemphasis on grades. In ethnic and institutional cultures that place significant value on high grades, it is common for students to perceive their marks as an indication of their personal worth and not just their academic ability (Pippin, 2014). This mentality can lead to an increase in stress and in some tragic cases students have even ended their lives upon receiving poor grades (Brilleslyper et al., 2012; Kohn, 2011; McMorran et al., 2017).

Gradeless Learning

Naturally, one solution to an educational system that heavily depends on grades to unreliably measure students' learning outcomes would be a system without grades. One example of this is the Pass/Fail system, with which the final course grade is simply a 'Pass' or 'Fail'. The threshold to ‘pass’ the course is measured by demonstrated examples of mastery of certain skills, which are often assessed qualitatively. Several institutions around the world have taken advantage of gradeless learning (McMorran et al., 2017). There is also promising evidence from numerous studies that shows the benefits of gradeless learning, such as significant improvements in psychological well-being (Bloodgood, Short, Jackson, & Martindale, 2009), reduced stress, anxiety and feelings of competition (Jacobs et al., 2014); and greater group cohesion (Rohe et al., 2006) compared to graded peers. Student surveys conducted by McMorran et al. (2017) indicate overwhelming agreement with and understanding of the intentions behind gradeless learning, such as easing students' transitions into higher education, developing life-long learning behaviours, and making daring choices with coursework; that is, encouraging exploratory learning and fostering a sense of discovery and innovation.

However, there is a concern that removing the incentive of grades could result in poorer learning attitudes. For example, surveys of students (McMorran et al., 2017) and faculties (McMorran & Ragupathi, 2020) at the National University of Singapore reveal that while both groups support the intentions of a gradeless system, they also had concerns about students paying less attention in class and skipping lectures once the pressure of receiving a bad mark was removed. As pointed out by Michaelides and Kirshner (2005), such fears are not entirely unfounded, as there is some evidence that also shows that students often spend less time and effort on modules that have pass/fail outcomes compared to graded ones (Michaelides & Kirshner, 2005). In the Software Engineering Technology program at McMaster University, an attempt has been made to overcome this hurdle by raising the bar on the skill competencies that the students are required to master in order to pass the course. With a curriculum laced with numerous challenge projects, a variety of assessments that are often administered as self-check points, an ePortfolio with a reflection component on learning, and an overall stringent requirement for the demonstration of competencies in order to pass a course, it is expected that students will not be able to simply pass through it with minimal effort.

Finally, it should be noted that the absence of a grade on assignments does not mean that learning cannot be facilitated through other means. Butler and Nisan (1986) found that students who received descriptive comments on initial assignments performed much better in subsequent tests on quantitative skills compared to peers who received grades and those who received no feedback (Butler & Nisan, 1986). One example in an engineering context is an intermediate programming course taught at Northwestern University in Illinois, in which the professor uses "critique-based assessment", whereby students send working solutions to a question, who then receive a detailed critique (Riesbeck, 2017). The students use this feedback to inform their next draft of the solution, which is again sent to the professor, with the cycle continuing until no further critiques need to be made. Cases such as these demonstrate the importance of detailed and constructive feedback in facilitating active learning amongst students, especially in the absence of letter and number grades. It is also important that students themselves to see the value of learning that goes beyond the grade point average..

Achieving this shift in perspective might be the most difficult aspect of a gradeless learning system (McMorran et al., 2017). Fortunately, as with most other facets of society, the pandemic has served as an impetus

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for a paradigm shift around teaching and learning. Many instructors (M. Levine, 2021) and institutions (Rickers, 2021) have seen this as an opportunity to experiment with gradeless assessments and have observed promising results.

6. CONCLUSION

The recent pandemic has not only brought new challenges to the education system but has also encouraged us to experiment with alternative methods of teaching and assessment that may potentially transform the practice of teaching and learning in the future. In this review, we have presented short summaries of the popular assessment strategies adopted in the virtual or hybrid learning settings, with an emphasis on the development of ePortofolio learning in engineer-based courses. In this context, we have also highlighted the utility of a gradeless learning system in fostering deep and life-long learning skills in students, while balancing rigorous training for competencies with student well-being.

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