STUDENT REFLECTIVE PRACTICE AS PART OF ENGINEERING PROGRAMMES

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ABSTRACT

Reflective learning can be defined as "*practice which involves the development of learning and understanding through self-review to help determine progress against goals and future learning needs*". In a CDIO context, the use of reflective learning has found its way into the most recent iteration of the syllabus while it can also be argued that self-review is, in particular, a part of Standard 8 - Active Learning. This work looks at a survey (n=38) carried out among academic staff involved in CDIO and in the wider engineering education community to establish the extent to which reflective learning is embedded in engineering degrees and how, at the highest level it is taught, implemented and assessed. The survey also looks at motivations, barriers and best practice in the field. Among the findings, respondents to the survey were enthusiastic about the topic as might be expected in a voluntary survey, however there was more skepticism as to whether students would see the value of the approach and so may not engage. Reflective journals and/or end of module reports and reviews were common tools used to embody reflective practice into activity, though these might be part of a more general activity or assessment and not be entirely focused around reflective practice. Key barriers to adoption of reflective practice included the pressure on an already overcrowded syllabus and students struggling to engage in the process, staff reporting that structure and frameworks need to be used to develop true reflections as opposed to simple records of events. The work concludes by highlighting some routes forward for the approach both in terms of implementation and possible development of the methodology.

KEYWORDS

Reflective Learning, Learning Approaches, Survey, Standards: 3, 7, 8, 11

INTRODUCTION

CDIO emphasises an active and engaged approach to engineering education with students being fully participating partners in their own educational and personal development, not simply acting as consumers of, or depositaries for, didactically delivered knowledge. The learning within CDIO programmes is often experiential, often integrating between disciplines. This is exemplified in a number of standards, including standard 5 : Design – Implement Experiences

and standard 8 : Active Learning. The learning experiences associated with these approaches may be authentic but may not always be as explicitly expressed as in more conventional methods. Further the breadth of integrated content may also expose students to their weaker and stronger areas in a more subtle way than traditional programmes with very discrete and often unlinked subject areas.

To fully realise the opportunities afforded by the authentic and integrated approach of CDIO, greater ownership of the learning process needs to reside with students and as such, skills in critical self-reflection to guide the learning needs and growth of each student, it can be argued, are an important – if not essential - part of the CDIO experience. Indeed, there is reference to student reflective practice in the rationale for Standard 8 ("….*they recognize for themselves what and how they learn"*) and as an assessment method (*Standard 11*). Meanwhile the most recent version 3.0 of the syllabus has seen this competence recognised with formal inclusion of reflective practice (*2.4.2 : Self-awareness, self-reflection, metacognition and knowledge integration* & *3.2.3 : Written communication > Reflective writing (write to learn)*) (CDIO (2022)). Further, the ability for students to self-reflect on competence levels and learning needs is an important skill required in the support of lifelong learning, as graduates move beyond the externally mapped learning associated with school, college and much of university education to a more self-prescribed pathway following graduation (Bergland (2018)).

This paper asks the degree to which reflective learning practises within the general engineering education community including but not exclusive to those utilising CDIO, examining motivations, methods and outcomes. This is then coupled to a survey of CDIO practitioners to understand the extent to which reflective learning appears within the curriculum, the value placed on this by students and staff, the impact of this approach and barriers to implementation. This highlights opportunities offered by this approach but also some of the cultural and practical challenges associated with brining in reflective practice.

LITERATURE REVIEW

Despite the overall recognition of the importance of reflective learning practices in professional education, there is no consensus on the definition and we can find various approach to describe this concept (Mann et al., 2009). According to Dewey's (1933:9) frequently cited seminal work, reflection is an "active, persistent and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it and the further conclusion to which it tends". From this perspective, reflection is a continuous process happening in community as a "meaning-making process" based on learners' experiences and ensuring a deeper understanding of these experiences at a different level (Rodgers, 2002). For Shön (1985), reflection is considered as an iterative process in which reflection of an experience produce a new understanding that will change the learners' reaction to the future experiences. This iterative reflection is often integrated in the various theoretical models of reflection (Mann et al., 2009). Regardless of multiple approaches and interpretation of reflective practice even inside of the same discipline, we consider it as a part of the process of lifelong learning allowing to individual learner being self-aware and critically evaluating own actions to develop their understanding. Consequently, self-awareness and critical thinking are regarded overlapping reflexivity in the reflective practice (Finaly, 2008).

Reflective practice is making an emerging contribution to Engineering Education (Sepp et al., 2015) to the professional development of engineering students' through numerous transversal or soft skills' development. In their four level conceptual model of reflective engineering, Klaassen et al. (2021) put emphasis on the development of these transversal skills, ideally in

a challenge-based education environment, for well preparing graduate engineering students to became a 'reflective engineer' able to answer to their future professional challenges. In the same line, Berglund's (2018) empirical study provided evidence of engineering students' skills development in their (1) personal effectiveness (personal management), (2) social competence (teamwork and communication), and the engineering professional role (engineering roles) through reflective practices. His work highlighted the potential benefits of reflective practices on engineering students' professional development allowing a better preparation for their future professional career. Also, the experience of student reflection is highlighted in a number of CDIO conference papers (e.g.: Junaid et al., (2018); Cheah et al., (2019), Seidel et al., (2011); Wallin et al., (2016)). Typically, these involve the most frequent implementation of reflective practice as part of project or problem based learning environment with tools such as diaries or journals used to help students draw out the learning from project experiences.

As Eshuis et al. (2022) pointed out in their recent study, students have a strong recognition of the importance of reflective practice for becoming a professional engineer but seem not satisfied with the current implementation of reflective practice in their curriculum. Surprisingly, reflection reports were the most frequently applied method in their study programs that was perceived by students as the least meaningful and they would prefer reflective conversations with study coaches indicating the important role of teachers in reflective learning. Similarly, several authors (Morgan et al. (2021:13) observed, despite the perceived value of reflective practice, engineering students' showed reluctance and a generally low level of reflection (only some students provided a meaningful reflection). As reflective practice is very different from the traditional teaching and learning practices, "instructors should provide this emphasis in the assignment instructions, alongside the reflective prompts". Therefore, teachers play an important role for giving clear assignment and guidance by supporting students' all along of their reflective practice in a persistent way (Cosgrove et al., 2014) over a longer period to a better benefit (Wallin et al. 2016).

Regardless of the difficulties in the implementation and evaluation, the use of reflective practice have numerous potential benefit for engineering students. One of the most important is the improvement of the academic performance and social engagement in their studies (Menekse et al., 2022). For George (2001), who reported also students' reluctance for this non-conventional learning practice, there are multiple benefits for engineering students like the development of a wide range of transversal skills (communication, lifelong learning, self-awareness of learning strategies) and a better efficiency in the professional work. In his current study, Zarestky et al. (2021) provided evidences that the use of reflective practice was helpful in the development of engineering students' metacognitive awareness, self-regulated learning behaviors, problem-solving, and critical thinking skills. As mentioned earlier, reflective practices happen in the interaction with others (Rodgers, 2002) therefore supporting students' relational skill and attitudes (e.g.: open-mindedness).

METHOD

To investigate the use of reflective practice in engineering degrees an online survey was developed to which academics involved in CDIO and Engineering Education in general were invited.

Survey Design and Approval

The survey featured a blend of demographic data including participant's subject areas, work role and geographical region. Primary data was then gathered using multiple choice and Likert type questions to gather data on the extent of reflective practice, methods used and attitudes to this approach. A final question was added to allow participants to optionally share good practice in this area or report practices which may not have worked as well as hoped. The survey was anonymous to encourage open responses. The survey and general data gathering and use processes were approved via the ethics committee of the College of Engineering and Physical Sciences at Aston University (ref : #EPS21011).

Participants

Participants were invited from the list of "People at CDIO Member Schools" on the CDIO website database. Invites went out to academics from all regions however the nature of current CDIO demographics meant some regions received greater coverage than others. Some invites also went out directly to others from the wider UK & Ireland CDIO community and the wider engineering education sector. Around 40 responses (n=38) were received and feature in this study.

Limitations

As with any voluntary survey, participants will be more predisposed to take part in surveys in areas of personal interest and this will skew results against those which might be gathered by a more general population of academic participants. It was also the case that many of the larger CDIO institutions had several people invited to take part and so it may be some responses may be replicated among colleagues. While offering some insight into techniques used in reflective practice and opportunities and barriers associated with its adoption, detailed drawing out of the specifics of these matters were limited by the use of a survey as opposed to an interview.

RESULTS

Demographics

Figure 1 shows some of the participant demographic data gathered in the survey highlighting a strong mechanical and aerospace cohort with most being at lecturer level.

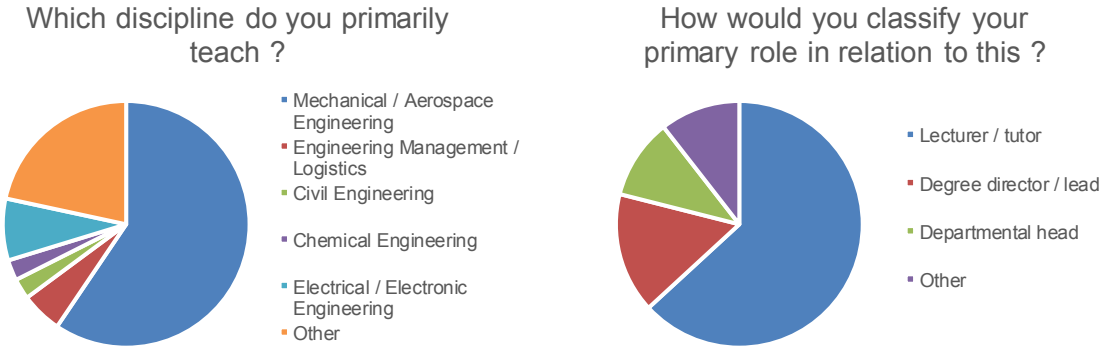

Figure 1. Partial demographic data of participants in survey

Implementation Approaches

Figure 2, shows some of the initial data gathered on how reflective practice is deployed. It is notable that reflective practice is embodied in range of activities, is indirectly assessed through these but it may often not be formally taught.

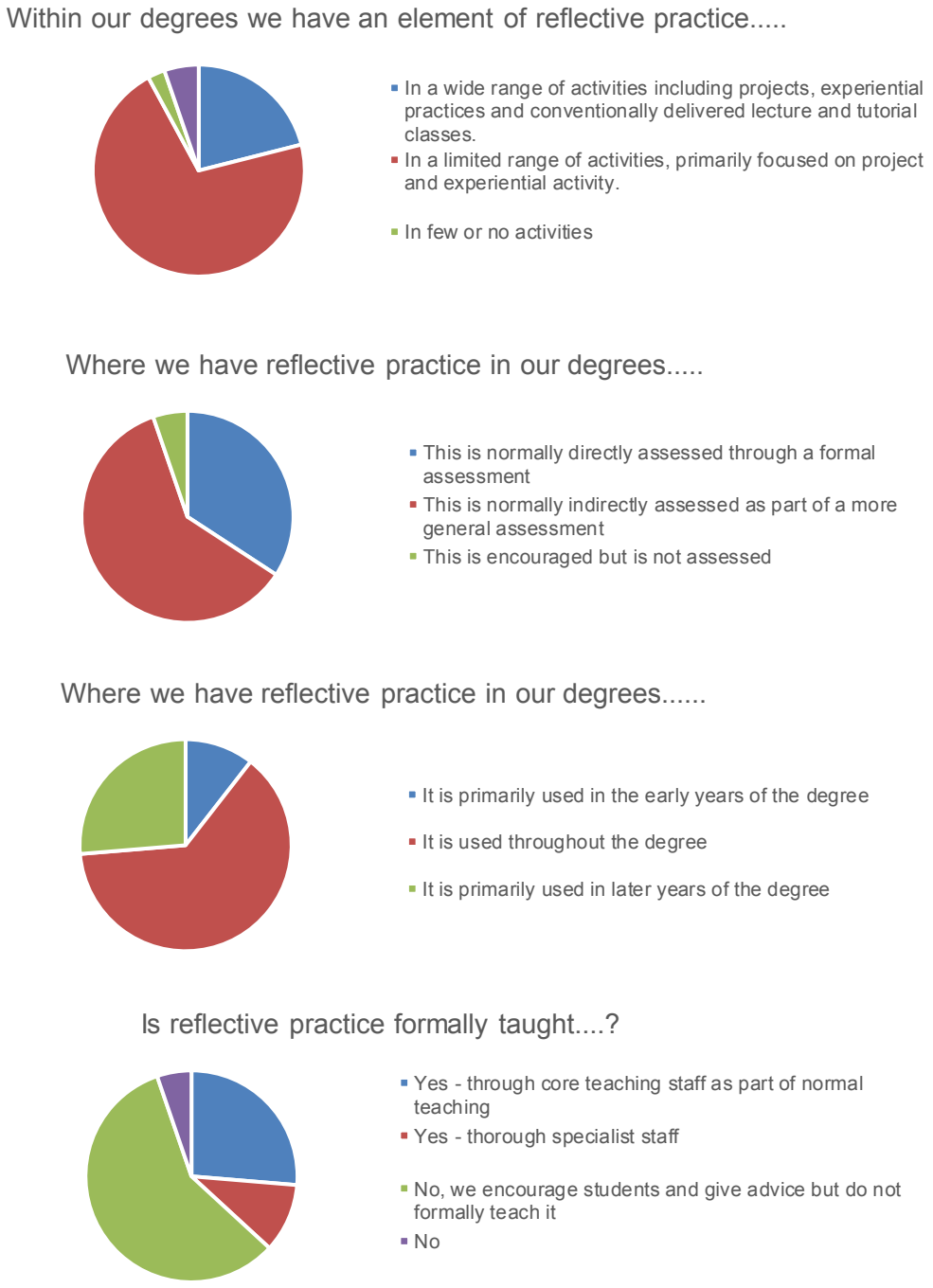

Figure 2 : Approaches to Implementation of Reflective Practice

Implementation Methods

Figure 3 highlights a range of different measures used by respondents to help embed reflective learning in degrees.

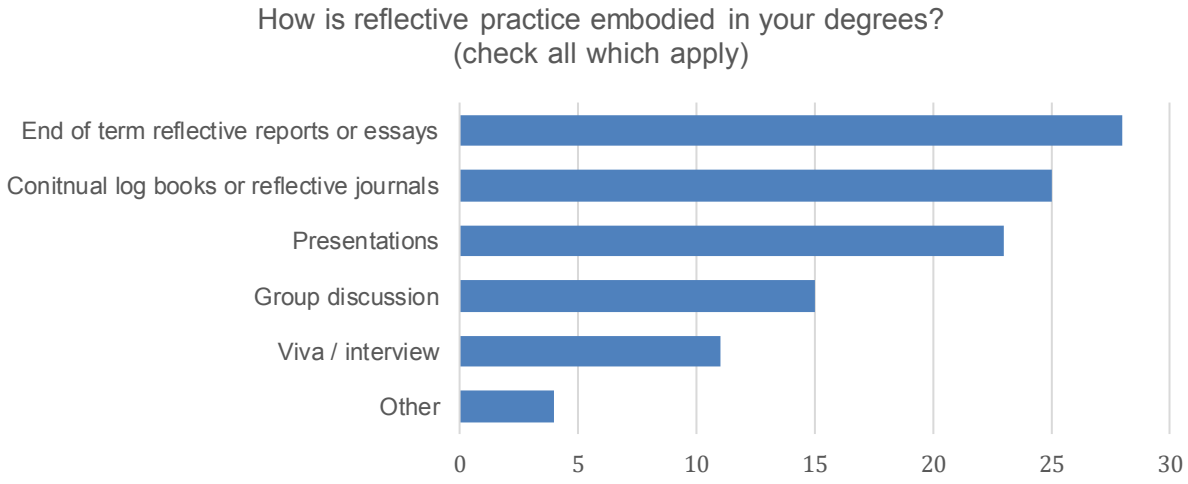

Figure 3. How reflective learning is embedded in degrees.

Perceived Importance

Figure 4 highlights different levels of perceived importance of reflective practice as recorded by the survey participants. As can be seen the survey participants were very enthusiastic about this theme but felt their colleagues may not be quite so positive and that there may be a further reticence or lack of awareness among students of the benefits of the approach.

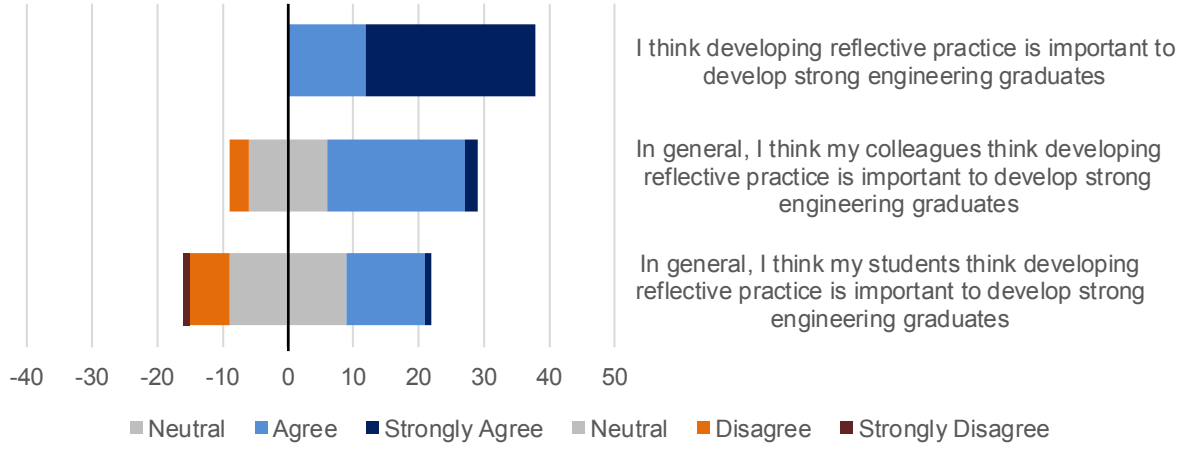

Figure 4 : Perceived importance of reflective practice

Barriers and hindrances

Figure 5 reports the degree to which participants felt certain factors act as barriers or disruptors which impact how reflective practice is deployed. Concerns regarding the ability to

accommodate the approach in a typically busy engineering curriculum gave greatest concerns while hesitancy of both staff and students to embrace reflective practice in the curriculum were also prominent.

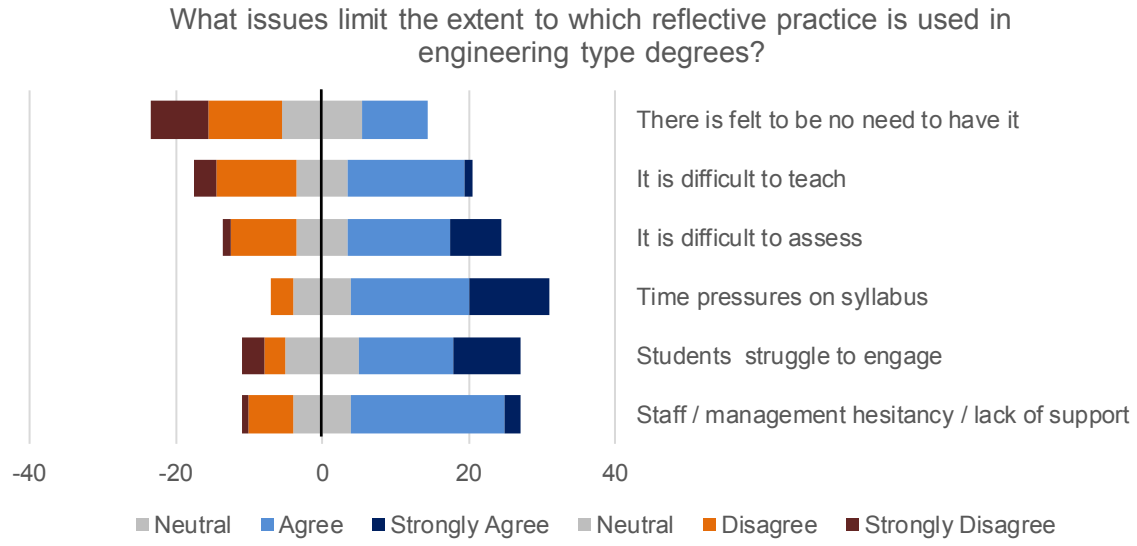

Figure 5. Factors hindering use of reflective practice

Benefits

Figure 6 illustrates a positive response to a range of potential benefits of reflective practice.

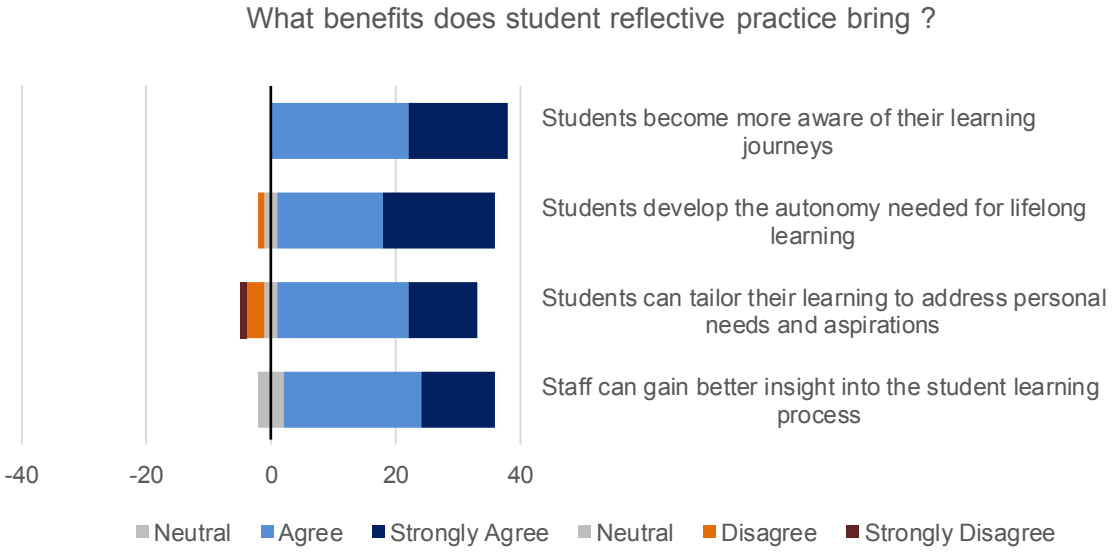

Figure 6 : Possible benefits of Reflective Practice

Learning from experience

In addition to the multiple choice and Likert scale questions, the survey also featured an opportunity for participants to share experiences of approaches to reflective practice with around 60% of them choosing to do so.

A range of activities were discussed by participants including project based activities with reflective activities including bi-weekly reports, end of module self-evaluations and peer and individual reflections. For example one respondent reported *"each student is required to perform a retrospective review of their own experience and how to enhance it in the next semester project in addition to a group evaluation of the work performed*".

Good practice was reported at different stages in the student learning journey. An introductory ice-breaking project, "Project Zero" was reported to lay foundations for reflective learning and *"create a positive attitude and experience for all the students as even those who perform poorly receive constructive feedback to help them with their first project*".

There were also mixed responses regarding what worked well with regard to how students felt about exposing their reflections to others with one participant reporting that *"I have tried this in various ways and have experienced a marked tendency towards non-participation in a public forum - it has to be very anonymous to work"* while whether the work was assessed or not could impact engagement *"Students are not willing to write or share reflections with personal tutors, perception is that it needs to be assessed to have value".*

Several reported that getting students to reflect effectively was sometimes difficult; *"very few actually reflected on their learning and the majority just reported what they did on the project"* with others reporting the need for significant support needed to go beyond simple reporting of experience and look forward; *"….needed guidance questions that point specifically to areas where we need students to reflect on, otherwise they tend to write narratives on what they had done"*. This however would not always deliver as hoped; *"We had rubrics to guide students but no explicit explanation are given. Students are expected to go thru' the rubric themselves, and as a result I don't think many did."*

While logbooks and reviews were quite common novel thinking included the use of role plays, *"where students are asked to reflect over the task and the development of the exercise, the group dynamic and their learning".*

DISCUSSION AND CONCLUSIONS

Reflective practice is widely considered by most CDIO practitioners as an important part of the skill set of both students and graduates but is not always recognized by students and can be difficult to implement into programmes through pressure on staff and curriculum time and hesitancy from colleagues and students to embrace the approach. It is a part of the CDIO methodology having found its way formally into the syllabus in the 2022 revision. It is also however a part of Standard 8 on active learning but may often get lost in interpretation with the focus of the standard on practical project type learning.

A wide range of different models and approaches are used to support reflective learning, though there appears to be no failsafe approach to implementation. While some methods work well for some students, for others, full engagement needs significant support and guidance.

The most popular approaches used to engage students in reflective learning were ongoing reflective journals or end of project reports with most of the academics participating in the survey using these approaches. These are pragmatically attractive in being fairly easy to administer and leaving a written record of reflection for assessment or review. Students often struggled with this approach however and could not provide meaningful personal reflection as opposed to simple recording of facts. This is likely to be a mix of factors with engineering students general writing abilities and an unfamiliarity with self, as opposed to tutor, review. Aspects relating to the personal nature of reflection have also been reported as an issue in other fields (Fernández-Peña, R et al (2016), Leering (2019) Thomson et. al. (2019)). Students can become reluctant or anxious to share weakness or vulnerabilities to tutors or can be concerned over privacy. It would be naïve to think these concerns are not present among engineering students.

There is clearly however no single approach to embedding reflective practice. A structured approach with a clear plan to guide students on reflection may help give them some technical confidence to understand their own weaknesses and potential growth areas however more subtle approaches may need to be used to breakdown the more personal sharing and critical review aspects which may hold some students back.

An area not fully explored in the survey was the longer term impact of reflective practice on students and into their graduate lives. Earlier work with graduates (Thomson (2019)) suggested reflective practice is valued once in the workplace - *"CDIO is a big part of my daily work day. It gave me the foundations of skills in working through projects. I still do weekly reflections on how my week has gone and what I should work on to improve.".* This too suggests that a fuller study on the efficacy of reflective practice could and should be looked at in more detail.

There is therefore future work which can be done to develop both reflective learning implementation strategies and appraise the longer impact on the growth of students and graduates.

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