Student Inclusivity in Digital Engineering Education

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Abstract: Over the past 30 months, Higher Education Institutes (HEI's) have through necessity transferred student engagement to a predominately online teaching and learning format. Notwithstanding the ongoing enthusiasm for digital pedagogy, the reality of online education delivery and performance of engineering students remains inconclusive. Indeed, it is only recently that the wider harms of the COVID-19 pandemic on student learning is beginning to be explored. Whilst the impact of the pandemic is far-reaching, this position paper challenges claims of 'inclusivity' frequently attributed to online and digital learning environments. There endures a risk that impediments to inclusivity such as digital poverty can be resolved by providing engineering students with laptops and digital devices. However, it may be contested that this approach is a simple and impoverished interpretation of challenges students from lower socio-economic status routinely encounter. Home environment and family background, personal circumstances and well-being, finance, access to digital infrastructure, IT hardware/software, digital literacy as well as the lack of in-person teaching individually and collectively impact on the student's ability to participate meaningfully and successfully with their engineering studies. Recent statistics reveal that the number of students dropping out of courses has increased and suggests working class students from the lower socio-economic backgrounds are disproportionately affected. Promoting fairness of access, institutional support, social mobility and an inclusive learning community arguably requires more than the distribution of digital devices. Multiple factors require sensitivity and investment before HEI's can confidently declare the establishment of an online, digital and hybrid learning community accessible to all.

Keywords; Inclusivity, Online, Working Class Engineering Education

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1. INTRODUCTION

A persistent and stimulating discourse within Engineering Education is the management and promotion of student inclusivity. Many Higher Education Institutes (HEI's) prepare and publish policy documents in direct reference to procedures and practices that the university will have endorsed to address the challenges of providing fair, equal and transparent access to both educational opportunities and learning resources for all students and especially those students who might otherwise be excluded or marginalized. Policy and by extension procedure and practice is frequently informed and supported by cross-university committees exploring discrete sub-topics such as equality, diversity and inclusion. This is also driven by alignment with United Nations (UN) Sustainable Development Goals (SDG). In particular, UN SDG 10 – Reduced Inequalities.

Notwithstanding ongoing understanding and development in student access, attainment and social mobility, endorsement of a Higher Education online teaching and learning environment exacerbates existing difficuites and introduces new challenges for a genuinely inclusive digital engineering education environment.

In the wake of the COVID-19 pandemic, online pedagogy is now mainstream. The past 30 months has witnessed a step change in the delivery of engineering education which remains unlikely to be reversed. Whilst the idea of online digital learning education has been a source of considerable debate for some time, consensus on the merits and drawbacks of online HE delivery remain inconclusive. Despite innovation in practice and continuing Higher Education enthusiasm for online learning environments, it is only recently that the wider harms of the COVID-19 pandemic on student learning is beginning to be explored (Scottish Government, 2022; Donnelly, R. and Patrinos, H.A., 2021). For engineering education, where a considerable emphasise relates to theoretical understanding, elements of practical dexterity and strong links between theory and practice, the debate and online challenges arguably become more complex.

There are multiple facets of online learning that merit exploration however, this paper explores student inclusivity in digital engineering education and the challenges connected with creating an online learning environment for all students regardless of personal and/or social background. There is an inherent risk that digital barriers to an inclusive online teaching environments and learning communities such as digital poverty may be resolved by providing engineering students with laptops and digital devices. However, it may be contested that emphasis on a hardware / software solution is an overly simple and impoverished interpretation of the difficulties students encounter. Especially students from a working class background. Indeed, recent statistics reveal that the number of students dropping out of courses has increased and suggest working class students from the lower socio-economic backgrounds are disproportionately affected (Scottish Government, 2022). The potential extent of the challenge should not be misjudged. Figures published by Scottish Funding Council Statistics (2022), disclose that 16.7% of Scottish-domiciled entrants to full-time first degree programmes were from the 20% most deprived post-codes. This represents a slight increase on previous figures (16.4%) and meets the 16% target set by the Commission on Widening Access. For many post-92 Scottish universities with a reputation for widening HE access, the mean figure of 16.7% is likely to be notably higher.

Other factors beyond digital poverty require sensitivity and investment when reflecting on the learning environment and upholding aspirations of student inclusivity. It may be contested that home environment and family circumstances, personal affairs and well-being, finance, digital literacy, access to digital infrastructure, IT hardware as well as lack of in-person teaching individually and collectively impact on the student's ability to participate meaningfully and successfully with their engineering studies. Addressing inclusivity in a profound and impactful way, requires a holistic and empathetic approach.

This is a position paper presented in a conventional format. Following a brief outline of the evolving digital teaching and learning environment, three potential impediments to student inclusivity are identified and reviewed. Namely, (1) studying and learning at home, (2)

digital infrastructure and (3) digital literacy. Thereafter the discussion details impacts and strategies intended to mitigate online teaching and learning practices that may hinder fair, transparent and equitable participation for all students, with an emphasis on students from a lower socio-economic background. In conclusion, the challenges facing engineering education is evaluated and avenues of further study identified.

2. ONLINE EDUCATION ENVIRONMENT

For many students, studying and learning at home connected to online learning environments offer the convenience and flexibility to balance educational ambitions, work-life and family-life commitments. There are also potential time and monetary savings in relation to the reduced commute to university and associated time and cost of travel expenditure. Previous studies of student engagement with online technology (Henderson et al, 2017) highlighted (1) organizing study (2) flexibility of study and (3) convenience and time benefits, as the three most useful practices. Indeed, it is interesting to note that proponents of online study frequently emphasis the management and logistics of achieving a better study/work-life balance (Henderson et al, 2017) as opposed to promoting the 'added-value' of digital pedagogy. Conversely, the convenience and agility of online learning requires to be offset against potential drawbacks. Indeed, studying and learning at home may compound existing inequalities and create new exclusions that were previously mitigated and better managed in an on-campus learning and study environment.

2.1 Studying and Learning at Home

During the pandemic, extended periods of studying and working from home was mandatory. All Scottish universities closed their campus facilities and was access restricted to a limited number of support staff with all teaching and learning activities transferred online. For students and staff, this rapid and intense shift to fully online pedagogy was very stressful. In addition, it is important to remember when promoting studying and learning at home that all household environments are different and represent a unique set of circumstances and accompanying challenges for individual students.

Studying and learning at home can be very unsatisfactory, especially in households that have limited space, shared space and potentially dysfunctional family circumstances. These factors individually and combined negatively disrupt the learning and study environment in a manner that is beyond the control of both the student and the university. Consequently, the prospect and convenience of study flexibility and agility is counterbalanced by a study and learning at home environment that is 'unfit for purpose' both in terms of setting and tone. Confronted with extended periods of disruption and an inability to 'escape', this is likely to adversely impact student motivation and enthusiasm for learning.

Whereas the student home environment and personal circumstances amplify inherent socio-economic inequalities and creates disparity in opportunity and access, an on-campus learning experience provides 'escape' and 'fit for purpose' learning environments. Attending university offers parity of access to learning and support services and provides social space for collaboration and quiet spaces for study. Other benefits include opportunities for laboratory work, refining engineering dexterity, encouraging in-person

engagement with academic staff and experiencing greater physical connection and personal affinity with their university.

2.2 Digital Infrastructure

Whist home and family circumstances undoubtedly differ, other significant factors are also at play including digital infrastructure and hardware/software resources. Digital infrastructure connects engineering students with their university's digital teaching resources, institutional vitual learning environment (VLE) and the students wider educational community. Without adequate digital infrastructure, student engagement will be restricted and constrained by their broadband connection and access reliability to digital infrastructure and quality of technology devices. This includes connection with service providers, hardware and software specification.

Where previous student learning experience was predominately campus based and access to digital infrastructure and technology hardware / software was universal for all students, studying and learning at home introduces a 'technology' variant. Digital connectivity to service providers varies considerably and can be very frustrating if connection and consistency of online services is unpredictable. A situation that may deteriorate if multiple users are connected at the same time. Indeed, the recent Scottish Government report exploring the wider harms of the COVID-19 pandemic on learners, students and staff within Higher Education, Further Education and Community Learning and Development in Scotland (2022, p.5), reported digital access as a concern and "reported that the digital divide is still very real and exasperating inequalities."

In addition to digital connectivity, students also require adequate hardware and software technology to support their learning needs. Again, considerable variations in hardware performance and software availability exist between individual students at the personal level. This potential digital technology inequality has been acknowledged by universities and many HEI's have established 'IT poverty' funds to offer help and assistance. However, the effectiveness of this approach with a focus on hardware / software would appear to be patchy when addressing cases of student inequality.

Anecdotal evidence from academic staff suggests engineering students routinely engage with their online academic studies using smart devices such as phones and tablets. This includes attending online lectures, completing online courseworks and online timed assessments via their portable handheld digital devices. Even where laptops can be borrowed and university support and funding is available, uptake would appear to be sporadic. Engineering students working with inadequate and dated digital infrastructure is likely to find it challenging and may potentially lead to poorer performance, error and stress. The annual report reviewing 2021 and published by the Office of the Independent Adjudicator (OIA, 2022), cited student complaints in relation to technical failures, digital skills and digital literacy.

2.3 Digital Literacy

In addition to the digital divide, the transfer to online digital technology has highlighted marked differences in the digital literacy of students. There remains a general perception

that students, especially the younger generation of students are familiar and comfortable navigating the digital environment. This is arguably misplaced. Whilst it is convenient to perceive engineering students as a homogeneous group, this standardised characterisation neglects the exclusive set of challenges that individual students face. Without a minimum standard of digital literacy, students will find it very difficult to engage efficiently and effectively with their engineering studies and navigate the plethora of terminologies, apps, download and uploads that other students and academic staff may take for granted. Indeed, it is not only students that can be bemused by the ever-changing technocratic environment and accompanying digital lexicon.

An inability to communicate effectively and seamlessly via the digital medium may impact negatively on student performance. For written work and especially online timed assessments, there may be issues with time, clarity of expression, editing, saving, uploading plus increased stress due to nervousness, potential for glitches and personal unease with the digital technology protocols. Indeed, in a recently published report (OIA, 2022), some student struggled to make the technology work effectively, whilst other students expressed keyboard and typing skills as restrictive.

3. RESEARCH

The research presented articulates the viewpoints of the author and draws on professional experience, literature and anecdotal evidence to better comprehend the existing and new challenges of creating and supporting engineering student inclusivity in an increasingly digital, online higher education environment. As a position paper, the intention is to shine a light on an important facet of engineering student engagement. It is anticipated that observations made will provoke and stimulate debate and encourage critical reflection on the subject and challenges in relation to student inclusivity. Including recognition of the unique and individual circumstances that accompany online, blended, hybrid engineering education. There are undoubtedly notable limitations and assumptions associated with the ‘personal’ approach adopted. This is readily acknowledged.

4. DISCUSSION

A convenient starting point for discussion is to concede that there is always going to be inequalities and instances of exclusion with regard to engineering education. University policy and interventions offer welcome assistance and whilst cases of inequality may be mitigated, many root causes remain unlikely to be resolved. In short, there is no silver bullet to resolve all situations that may result in student exclusion and marginalization in HE.

That said, whilst the HE sector has arguably been at the vanguard of wider policy making to promote wider access, opportunity and inclusiveness, especially for working class communities; the significant transfer of education and learning to an online, digital format introduces another notable hurdle to the aspiration and creation of an inclusive engineering educational community. Especially as online learning environment(s) introduce complex economic, social and technology variables that remain largely beyond the influence of the university. Whilst there are many avenues to explore, three key areas selected for comment

relate to student inclusivity in digital engineering education: namely, (1) studying and learning at home, (2) digital infrastructure and (3) digital literacy. All three conspire individually and collectively to impact on the student's ability to participate meaningfully and successfully with their engineering studies.

Endorsement of online education delivery and student 'learning and study at home' clearly offers flexibility, freedom and convenience to access learning environments but at what detriment to student learning? And at what harm to student inclusivity? Online learning is not without risk of learning loss and exclusion. For students struggling with their 'unfit for purpose' learning and studying at home environment, they may no longer feel an integral part of an identifiable engineering learning community and may perceive themselves as 'distant' learners as opposed to co-opted member of a 'community' of learning. This cohort of distant learners remote from the learning community and increasingly isolated from previous taken-for-granted on campus highly social environments are at increasing risk of dropping out of study. The feeling of marginalization and exclusion may be compounded if the digital infrastructure and access to digital technology is also lacking. A stated previously, students most at risk are likely to be working class students from the lower socio-economic backgrounds. Indeed, initial statistics offer an early insight that this student demographic are disproportionately affected (Scottish Government, 2022).

Whilst acknowledging and accepting the step change in higher educational delivery brought about by the COVID-19 pandemic, it remains especially important for engineering education that a practical academic balance is sought between online activities and on-campus learning and studying. A balanced or hybrid approach will assist in mitigating the unfavorable impact(s) of an 'unfit for purpose' learning and study at home environment. In addition, widely promoted and universal access to university funding opportunities for digital hardware / software will also offer assistance. However, more research is urgently required to establish the workable parameters, evaluating the potential pitfalls and benefits of a 'practical' and 'affordable' hybrid solution.

Indeed, hybrid is now an everyday expression within higher education discourse and to date 'hybrid' in higher education would appear to mean different things to different people. Consequently, anecdotal evidence would suggest that current engagement with hybrid delivery is ad-hoc, variable and largely determined at a local level, devoid of an overarching evidence-based and informed university strategy. Under these circumstances, the balance derived and the practical parameters established may owe more to addressing academic teaching pressures, resource availability and convenience of knowledge transfer than a keen focus on pedagogy, student learning, and student inclusivity.

Understanding the language of digital technology and dexterity of use is also a notable variable and potential barrier for engineering students. Without a minimum standard of competency, digital literacy will undoubtedly impact negatively on student performance and limit access to learning environments. Addressing student digital literacy also requires further research to better understand the scale and scope of the issue. It may be suggested engineering students will be required to demonstrate an entry standard of digital literacy prior to starting their engineering programme of study or alternatively, incorporate

fundamental digital knowledge, understanding and practice within a structured and reviewed student-focused continuous learning development programme. Not dissimilar to the short courses routinely made available by HEI's to academic staff to promote continuous professional development (CPD).

One notable feature of online educational delivery that would appear to trigger higher levels of student anxiety is online timed assessments. In many ways, online timed assessments collectively exemplify the social, digital and dexterity issues encountered by many engineering students and likely to disproportionately impact on students from a working class background. For some, the home environment may be unfit for purpose, the infrastructure and connection may be unreliable and digital skills may be lacking.

The lack of typing skills is an interesting remark (IOA, 2022). For example, for online timed assessments students are typically given the option of uploading hand-written scripts or alternatively typed scripts. At a recent 2022 online timed assessment for an engineering cohort, students could elect to upload hand-written responses or alternatively upload typed responses. For this assessment, forty-seven students uploaded an online digital script, see table 1 – Evaluation of Online Timed Assessment Scripts.

ASSESSMENT	TOTAL: No. Students. 47	TYPED: No. Students 26	HAND-WRITTEN: No. Students 21
ENG. / CODE:	Ave: 60.92%	Ave: 64.17%	Ave: 56.90%

Table 1: Evaluation of Online Timed Assessment Scripts

Reviewing the scripts, twenty-six students upload typed answers and twenty-one students elected to provide hand-written answers. All scripts were marked anonymously. The average mark for the engineering student cohort (47 students) was 60.92%. Categorising responses as either 'typed' or 'hand-written', the average mark for 'typed' was 64.17% (26 students) and the average mark for 'hand-written' was 56.90% (21 students).

The difference between the two groups (Typed / Hand-written) for the same online timed assessment is 7.27%. This represents a curious percentage range in student performance based on typed / hand-written answer scripts. Whilst it is readily acknowledged that multiple variables exist and a more rigorous and robust evaluation of online timed assessments is required, the initial supposition and pilot outcome is thought-provoking and arguably worthy of future more detailed exploration. Are some engineering students disadvantaged due: (1) their study and learning at home environment?, (2) their digital connection and technology?, (3) their digital dexterity including their lack of typing skills? In addition, does this choice in communication preference re: typed or hand-written introduce an unconscious bias from the perspective of the marker?

Dealing with the thorny issue of online timed assessments, university IT suites could be adapted to conduct 'paperless' online timed assessments. This would part-address the serious ongoing issue of digital poverty especially in relation to assessment criteria.

Creating an on-campus IT facility as an examination suite, it would also be realistic and practical to have IT support available for students who may have knowledge and understanding issues with IT and digital applications. This would mitigate recurrent issues of delayed download and late upload of timed online assessment. Having access to IT support would also help alleviate anxiety and student stress levels. Importantly from an inclusiveness perspective, the on-campus controlled and managed environment will offer the same facilities and support to all engineering students regardless of personal socio-economic background. For assessment of student knowledge and understanding, this will promote fairness of access, parity of technology, universal university support and educational provision in addition to a designated, controlled and calm space away from potentially distracting family / work environments.

4. CONCLUSION

At its core, the issue and challenges of student inclusivity in digital engineering education is about the 'The Haves and the Have Nots.' Those students that have good access and those students that do not. It is a social class divide framed under the guise of digital environment, technology and literacy. Counter to the perceived and often repeated benefits of online learning and study, increasing engagement and reliance on digital education and online delivery in universities exacerbates existing inequalities and creates new ones.

Addressing the inherent social, digital and literacy divide to promote student fairness and inclusivity will require alternative and new strategies. There are unlikely to be easy, quick or cheap solutions to these complex problems. An uncomplicated albeit partial solution to mitigate online inequality and marginalisation of engineering students is to advocate more university on-campus activities. However, a return to pre-COVID-19 style of education engagement remains unrealistic. In the current climate of hybrid hype and enduring enthusiasm for digital delivery, a restorative balance between online and on-campus education is to be desired. Exactly where this restorative balance between online and on-campus resides is now a key question for engineering education. At present, significant investment is required before HEI's can confidently declare an online, digital and hybrid student learning format and experience that is equal, transparent and accessible to all.

5. REFERENCES

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