HIGHER EDUCATION PEDAGOGIES

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ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/rhep20

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To cite this article: T. P. Doss, N. F. Allett, G.J. Woods, G. Poursharif & G. L. Knight (2021) Effective measures of tailored learning support for Engineering Work-Based Learners in HE: A Case study, Higher Education Pedagogies, 6:1, 66-78, DOI: 10.1080/23752696.2021.1882327

To link to this article: https://doi.org/10.1080/23752696.2021.1882327

HIGHER EDUCATION PEDAGOGIES
2021, VOL. 6, NO. 1, 66–78
https://doi.org/10.1080/23752696.2021.1882327

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ARTICLE

Effective measures of tailored learning support for Engineering Work-Based Learners in HE: A Case study

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ABSTRACT

Since 2004, Aston University has been delivering work-based learning (WBL) engineering degrees to key UK Energy sector employers, such as National Grid. National measures for widening participation in HE, such as the Degree Apprenticeship Levy, have led to significant changes in learning background diversity of WBL cohorts, consequently increasing student requirement for additional learning-support in HE Institutions (HEIs). To address these challenges, an intervention strategy was formulated in collaboration with Aston University's Learning Development Centre. Our methodology gradually embedded a provision of tailored learning-support sessions/workshops in mathematics and effective communication skills within WBL curricula. Integrating this support has led to marked increases in student engagement,grade-attainment, and stakeholder satisfaction. This case study is pertinent to HE's current STEM sector focus on developing WBL programmes, where the flexible methodologies established here can serve as practical models for other HEIs in the delivery of 'in-employment' education, in response to the fast-changing workplace.

ARTICLE HISTORY
Received 1 July 2019
Revised 24 September 2020
Accepted 22 January 2021

KEYWORDS
Work-based learning (WBL); learning Development; degree Apprenticeships; learning support in STEM HEIs

Introduction

The UK engineering sector is facing an annual shortfall of approximately 59,000 engineering graduates and technicians by 2020 (Neave et al., 2018). To address this skills gap, the UK Higher Education (HE) sector introduced WBL engineering programmes (Nixon, Smith, Stafford, & Camm, 2006), in collaboration with employers, to attract non-traditional students, such as mature students and/or those without formal qualifications (Tierney & Slack, 2005).

Over the past five years the range of WBL degrees have evolved to include Foundation Degrees (deliver up to level 5) and Degree Apprenticeships (DAs) (deliver up to level 7). DAs, created in the government's 2015 apprenticeship reforms, provide higher-level skills to current employees, with an apprenticeship levy (collected from employers with annual payrolls exceeding £3million) used to cover apprenticeship training. Smaller

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employers (not paying the levy) have up to 90% of apprenticeship training costs covered by levy funding (Office for Students, 2019).

The resulting rapid growth in the number of DA programmes has increased the diversity of WBL/DA students, when compared to students enrolling on full-time STEM HE courses. More mature students undertake WBL/DA programmes with only 63% of STEM apprenticeships under-21 years old and two-thirds being male, compared to less than 30% of women enrolled on full-time Engineering and Technology HE courses. Furthermore, 30% of WBL/DA students come from underrepresented areas, POLAR quintiles 1 and 2, compared to 26% of full-time students (Office for Students, 2017).

WBL/DA programmes also differ to on-campus, full-time programmes, with delivery patterns of residential block-delivery, evening-delivery, summer boot-camps, day-release, online/distance-learning, and blended/distance-learning, with programmes developing teaching delivery patterns to address the need and preferences of employers while maintaining academic quality (Universities UK, 2019). Inevitably, WBL/DA programmes require students to undertake a significant proportion of their education as distance/online learners, who have to balance the commitment of full-time work with HE study.

Educational issues of part-time and mature student attainment are well-documented, with these students more likely to identify as 'non-learners' who self-doubt their ability for successful participation in HE (Fragoso et al., 2013; Goodchild, 2019; Howard & Davies, 2013). Mature students also self-report low mathematics self-efficacy and high mathematics anxiety in comparison to traditional students (Jameson & Fusco, 2014), with students returning to academic study after a break unsure of tutors' expectations and support provisions (Bowl, 2001; Tierney & Slack, 2005). WBL/DA students can also lack preparedness for HE due to differing entry qualifications (Fragoso et al., 2013). O'Shea, Lysaght, and Tanner (2012) highlighted that students with a competency-based vocational education, struggled with the theoretical orientation of HE, finding independent study and preparing academic assignments particularly challenging, with part-time and mature students requiring more support on examination techniques and/or with research and writing skills for self-guided projects (Lee, Marsh, & Parker, 2010). Thus employers, academics and employees commonly suggest that WBL/DA learners should receive support with the development of study skills relating to assignments, presentations and exams (Stephens, Doherty, Bennett, & Margey, 2014).

Different academic backgrounds and entry qualifications resulting in students entering HE unprepared for the transition is becoming a sector-wide issue (Gallimore & Stewart, 2014). To enable better student transition, more HE Institutions (HEIs) are instigating additional academic support services, that provide students with the development of more generic academic skills, to enable better attainment and enhanced transition (Dalrymple, Kemp, & Smith, 2014; Hultberg, Plos, Hendry, & Kjellgren, 2008). These Learning Development Centres (LDC), are generally on-campus services, providing a range of academic tools such as mentoring/peer-assisted learning, one-to-one support, diagnostic tests, technology (e.g. e-learning) and introductory HE courses, such as focusing on socialisation and deep-approach to learning, to support module cohort attainment and provide individualised learning (Hultberg et al., 2008; Lake et al., 2017).

Aston University has been delivering Engineering WBL programmes for over 15 years. In the past 5 years, the increasing student academic diversity, has resulted in growing demand for more generic support related to engineering mathematics and academic/technical writing and oral presentations. Our WBL engineering students were struggling to access LDC support, due to their teaching timetable and studying at a distance. We also observed a steady decline in student attainment and student engagement, with growing student dissatisfaction.

To address these challenges, we implemented tailored learning support embedded within our WBL curricula in collaboration with the LDC. This case study will detail how we implemented and modified our student support, to better suit the students' academic requirements and discuss how these approaches have influenced WBL student engagement and attainment. With more HEIs adopting WBL/DAs, this case study will provide a valuable insight into the different pedagogical delivery methodologies required for running WBL and DAs.

Methodology

In response to requests by our WBL students and their employers for additional academic support, a partnership between the programme team and the LDC was established. As tailored interventions are better in helping students' understanding of specific assignment requirements (McWilliams & Allan, 2014), rather than generic 'bolt-on' sessions which can decontextualize skills from the discipline (Allan &Clarke, 2007; Wingate, 2006), we adopted an integrated delivery of support within our WBL Foundation Degree (Two Year) Programmes. We implemented both communication and mathematics skills support strategies, respectively, tailored around our Year Two Work-Based Project, and Year One and Two Mathematics modules, and their corresponding assessments.

The learning support methodologies implemented were evaluated annually through programme reviews, including module surveys, student feedback and evaluation of student attainment and progression. This led to yearly adjustments in both support methodologies (Figure 1) that included further tailoring of the type and amount of support provided, as well as changes in the assessment approaches implemented.

Communication skills support intervention strategy

The communication skills learning support strategy was designed to support the assessment of the Year Two Work-Based Project module which is undertaken by second or final-year students, who are provided with initial academic guidance and additional LDC support in the latter half of their first year. This project module entails four assessment elements encountered in the following order: 1) Intermediate Project Presentation; 2) Intermediate Project Report, 3) Final Project Report; and 4) Project Viva.

LDC bespoke sessions were first initiated in 2015/16 (Figure 1), with an induction session for new students (Cohort B) introducing HE study and strategies for part-time and distance learning, as WBL students, due to varying experience and qualifications, can be underprepared for University transition (Fragoso et al., 2013; O'Shea et al., 2012). Three communication sessions for final-year students (Cohort A) were also developed, as

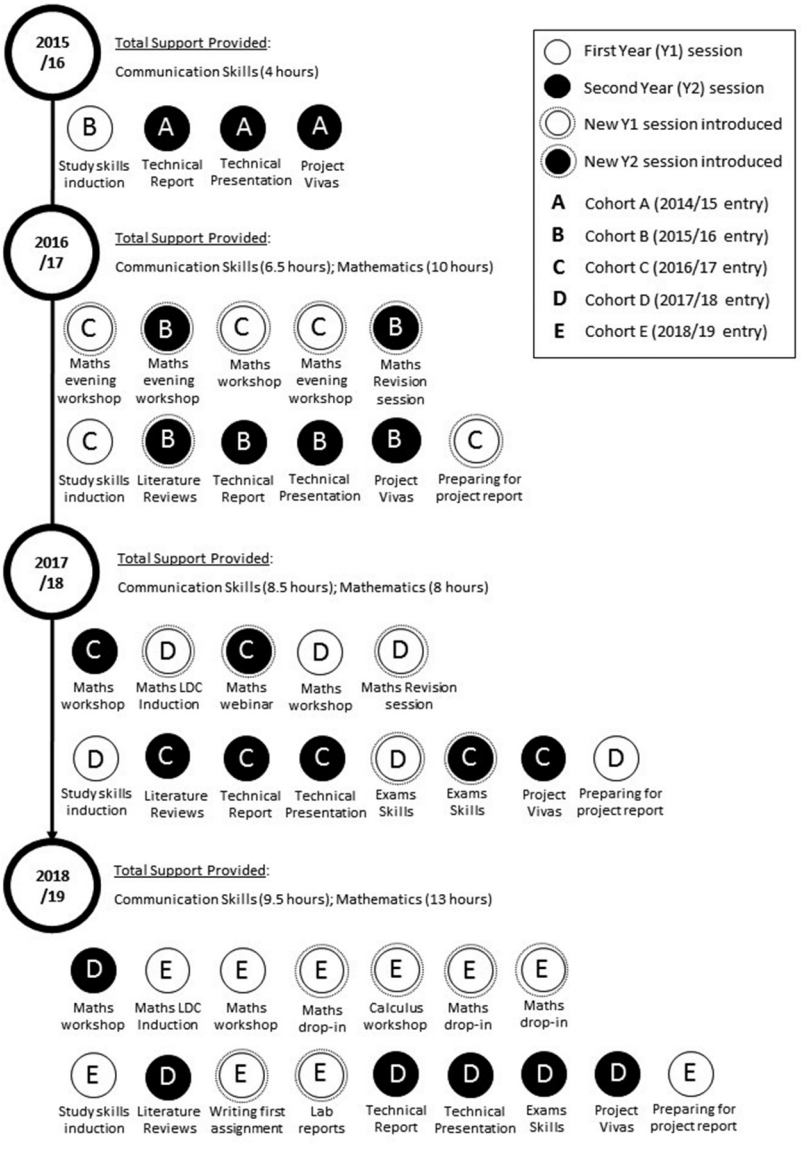

Figure 1 LDC Intervention Strategy: Sessions and Workshops 2015-2019

separate skills sessions have been shown to help build students' confidence and development in self-assessment (Chadha & Nicholls, 2006). These sessions were based on: technical report writing, giving technical presentations and preparing for project vivas, and provided opportunity for students to reflect, and discuss their strategies and preparation of the assignment. The sessions also included exploring examples of good practice, such as exemplars of past student work. The use of exemplars combined with peer-discussion and teacher-led interaction can help students understand the standards of assessment (Hendry, Strong & Bromberger, 2012; To & Carless, 2016) and assist the learning of a writing genre (Amos & McGowan, 2012).

In 2016/17, in response to 2015/16 students requesting project-writing guidance earlier in the academic year, two further sessions were built-in; 'preparing for your project report' for the new 2016/17 first-year students (Cohort C) and a session on 'writing literature reviews' for the returning final-year students (Cohort B). This served in providing integrated support for the duration of the project cycle.

In 2017/18, due to the growing variation levels of the students entering the programme (Table 1), sessions focusing on revision and exam strategies were introduced (for Cohorts C and D). Finally, in 2018/19, to further support the transition to academic study, two first-year sessions were developed focusing on writing assignments and laboratory reports (Cohort E).

Mathematics support intervention strategy

Difficulties in mathematics and statistics is one of the major obstacles to successful HE study, with mathematics and statistics support centres essential towards helping students develop their mathematical skills and confidence (Kyle & Kahn, 2009).

From 2015, the proportion of WBL students with more diverse academic backgrounds significantly increased (Table 1), and over the next two academic years a decreasing trend in grade-attainment in mathematics modules was observed (Figure 2 and Figure 3). This led to the formulation of our mathematics learning support methodology, tailored around the Year One and Two Mathematics modules.

Starting in 2016/17, we introduced LDC mathematics support workshops, for Cohorts B and C (Figure 1), as non-mandatory evening sessions. Though these evening sessions were well-attended, students highlighted a preference for future sessions during the day due to their strenuous 9am-5pm timetables, making evening attendance difficult.

Based on Cohort B/C feedback and grade-attainment, further mathematics support sessions for 2017/18 were developed, and embedded within the scheduled block-release module delivery, on a non-mandatory basis. Having timetabled sessions meant that students could plan which sessions to attend and were well-prepared with specific queries. Moreover, due to the continued decline observed in grade-attainment (Table 2), in 2017/18 a 'Maths LDC Induction' session was added whereby the LDC team was introduced to 2017/18 first-year students (Cohort D) at the start of the academic year, in addition to the 'Maths Revision' and 'Exams Skills' sessions (Figure 1). For returning final-year students (Cohort C) a new 'Maths Webinar' and an 'Exams Skills' session were also added. As the students are on block-release, the maths webinar was introduced to bridge the gap between their times on campus and ensure their steady progression in mathematics. The sessions were recorded and aided students' revision of material during the exam period.

Table 1. Student cohort profile: academic background.

Cohort	Academic Year of Entry	Number of Students	Students with Non-Traditional Entry Qualifications (%)	Mature Students (%)
A	2014/15	46	8.5	38.3
B	2015/16	69	22.5	57.8
C	2016/17	54	29.6	53.7
D	2017/18	51	42.3	53.9
E	2018/19	37	40.5	62.2

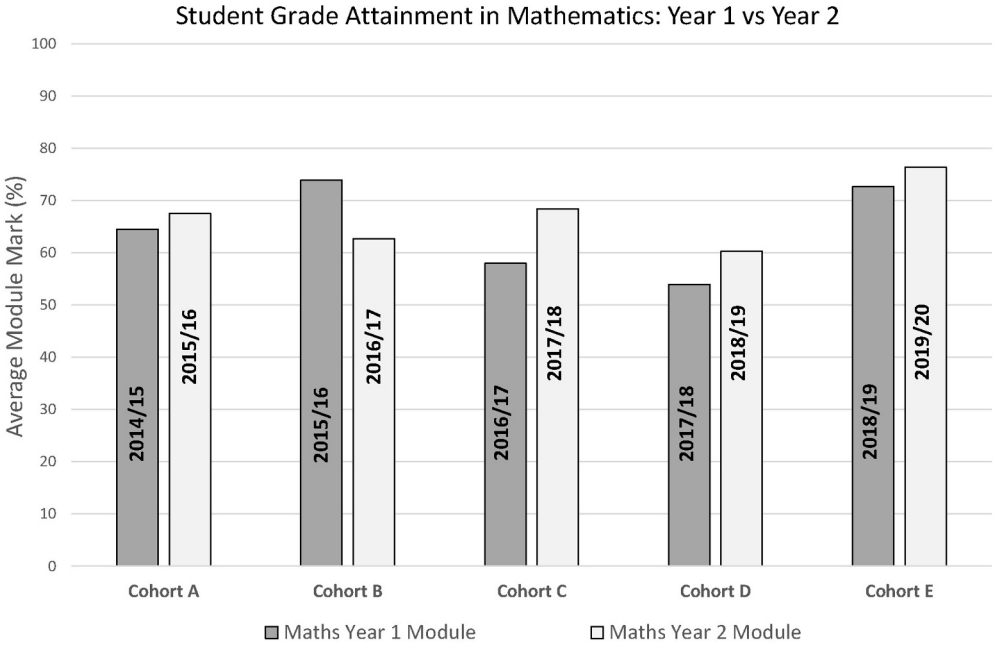

Figure 2 Student Grade Attainment in Mathematics: Year 1 vs Year 2

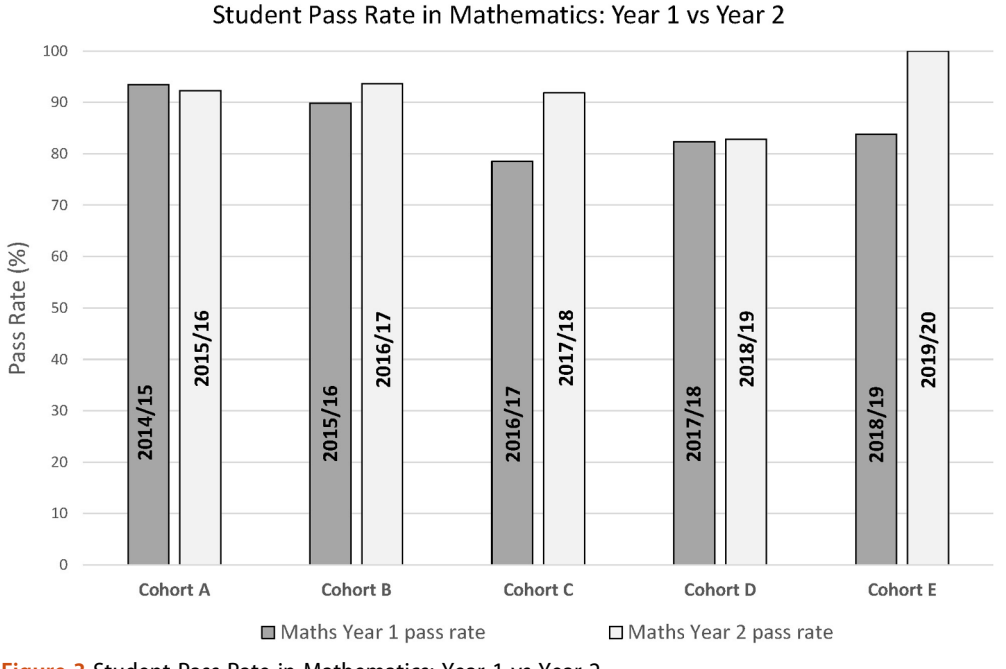

Figure 3 Student Pass Rate in Mathematics: Year 1 vs Year 2

Due to relatively low student attendance in 2017/18, followed by a direct request from the students' employers, in 2018/19 all LDC sessions required compulsory attendance. Moreover, difficulties in tracking early student progress and engagement in Year One

Table 2. Student attainment of cohorts A to E.

Cohort	Academic Year	Maths Module (Year One)		Maths Module (Year Two)		Project Module (Year Two)	
		Average module grade (+/- SD)	Module pass rate	Average module grade (+/- SD)	Module pass rate	Average module grade (+/- SD)	Module pass rate
A	2014/15	64.5 (+/-18.3)	93.5				
	2015/16			67.5 (+/-18.9)	92.3	64.3 (+/-11.7)	91.7
B	2015/16	73.9 (+/- 17.9)	89.9				
	2016/17			62.7 (+/-21.4)	93.7	64.2 (+/-10.1)	96.2
C	2016/17	58.0 (+/-21.4)	78.9				
	2017/18			68.4 (+/-19.6)	91.8	64.9 (+/-9.3)	95.7
D	2017/18	53.9 (+/- 18.9)	82.4				
	2018/19			60.2 (+/-20.8)	82.9	66.5 (+/-11.8)	96.3
E	2018/19	72.7 (+/- 25.2)	83.8				
	2019/20			76.3 (+/-16.1)	100	(Not available yet)	

Mathematics and a continued decreasing trend in Year One Mathematics grade-attainment, resulted in replacing the previous, single coursework assignment with more formative and summative assessments, to enable more effective progress and engagement monitoring. Therefore, for Cohort E (in 2018/19), a formative 'Maths Diagnostic Quiz' was introduced as a preliminary screening mechanism for new students. This quiz identified areas of weakness in the student body's mathematical knowledge base, which the LDC then used to tailor more bespoke support. This individualised learning approach has been shown to help overcome maths anxiety and benefit results (Patel & Little, 2006). The new summative assessment strategy still included an end-of-year examination element, but also incorporated two Class Tests. Within science-based subjects, testing a learning event encourages greater engagement with the material (Brame & Biel); therefore, the Class Tests were conducted under real examination conditions, providing students who had not sat any/many exams prior to their HEI attendance with an experience of exam preparation. The Year One Mathematics strategy employed in 2018/19, was also implemented in a similar manner in the ensuing academic year, 2019/20.

Data analysis

The pedagogical effectiveness of the Communications Skills and Mathematics intervention strategy, has been assessed on the Year Two Work-Based project module and Year One and Two Mathematics modules assessment results, with a particular emphasis on the progression through each academic year and overall transition between the two stages for each particular student cohort. Module information analysed was based on student attainment data for Cohorts A to F, from 2014/15 through to 2019/20 (Table 2), with

student engagement and satisfaction drawn from first- and final-year students surveys conducted towards the end of 2018/19.

Results and discussion

Student attainment with communication skills interventions

The success of this intervention strategy can be illustrated by the increasing student attainment in the Year Two Work-Based Project module, where an increase in the average module mark was observed from 64.3% (Cohort A) to 66.5% (Cohort D), (Table 2). The pass rate also increased from 91.7% to 96.3% in this same period, with 4.5% increase in pass rate seen in Cohort B (2016/17), who benefitted from the study skills induction in their respective Year One (2015/16) and then further support with literature reviews in their Year Two. The introduction of writing support resulted in higher average grades for the written 'final report' element of the project assessment, which increased by over 1% each year from 67.3% (Cohort B – 2016/17) to 70.3% (Cohort D – 2018/19). Our data also showed that 73.2% of Cohort B, 69.7% of Cohort C, and 81.2% of Cohort D made an improvement between the interim report and final report grades, highlighting the attainment benefits of introducing the workshops related to report writing and literature reviews. The current impact of the introduction of communication workshops for Cohort E related to writing assignments and laboratory reports will only be measurable, in relation to the impact on the project module scores, at the end of academic year 2019/20. Over the past 4 years, the assessment scores of the Interim Project Presentation and Viva have remained stable, with average marks of 68.89% and 64.69%, respectively.

Student attainment with mathematics skills interventions

From 2015/16 to 2017/18 there was a decreasing trend in grade-attainment and pass rate by Cohorts B to D (Figure 2 and Figure 3). The average grade for first-year students in Cohort D had decreased by over 10% compared to Cohort A, and pass rates had dropped to 78.9% for Cohort C (Table 2). As previously discussed, in 2016/17, the LDC began to offer mathematics support to Cohorts B and C in the form of 'Maths Evening Workshops' for both first- and final-year students and 'Maths Revision Workshops' for final-year students (Figure 1). The success of this strategy was not initially clear, with Cohort C obtaining even lower grades in the Year One Maths module, than the previous Year One (Cohort B), who had no additional mathematics support. Furthermore, the attainment figures of Cohort B in the Year Two Maths module also declined significantly from 73.9% in their Year One Maths module (2015/16) to 62.7% in their Year Two Maths module (2016/17).

The increased support started to have a positive impact on mathematics attainment for the new 2016/17 students (Cohort C), with an increase from 58% in their Year One Maths module to 68.4% in their Year Two Maths module. Furthermore, as Cohort C had the lowest Maths Year One grade-attainment and pass rate to-date, the increase in their Year Two Maths (2017/18) score by over 10% demonstrated the effectiveness of the additional support.

This trend was not as clear for Cohort D (2017/18), where Year One Maths grade-attainment dropped to 53.9%, the lowest average score ever recorded for these WBL degrees. However, this decrease could correspond to the cohort with the largest academic diversity of 42.9% WBL students enrolling with non-traditional qualifications (Table 1); an increase of 12.7% compared to Cohort C (2016/17). Although the average grade had decreased, the pass rate for the Year One Maths module increased by 3.5% to over 82% in 2017/18, with the same pass rate for the Year Two module.

An interesting finding of the diagnostic screening, introduced in 2018/19 (Cohort E), was the diversity of mathematical ability within the cohort, with grade-attainment ranging from 5.7% to 100%, and scores following a bi-modal distribution peaking around 40% and 95%. This range of skills and knowledge was a reflection of the diversity of student backgrounds in the cohort. This bi-modal distribution is indicative of the student entry qualifications. In total, 91% of Cohort E students who failed the diagnostic test had non A-level backgrounds. Similarly, the failed diagnostic tests recorded from Cohort F (2019/20) all corresponded to students with non A-level backgrounds. Cohort E results in the Year One Maths module assessment showed a steady improvement in grade-attainment, with average marks increasing from 62.7% in the diagnostic test, to 69.3% in Class Test 1, 74.4% in Class Test 2 and 72.7% in the Final Examination (Table 2). A similar trend was observed in 2019/20 for Cohort F (data not shown here).

As described above, the implementation of the Mathematics Skills interventions demonstrated overall positive results; the initial (2016/17) support on 'Maths Revision Skills', followed by embedding the mathematics sessions/workshops within the standard block-delivery (2017/18) was seen to have a positive impact on student progression and both student and employer satisfaction. In 2017/18, we also found that introducing our students at the start of Year One to the LDC, resulted in increased use of other LDC support services by these students, particularly in relation to one-to-one sessions. Before the implementation of this introduction session, the annual average engagement for Cohort B was three and zero occasions for Year One Maths and Year Two Maths modules, respectively, which increased to 68 and 51 occasions, respectively, for Cohorts C to E.

The introduction of the diagnostic test, enabled the programme and LDC team to gain a much clearer understanding of individual student ability and the opportunity to monitor student progress from the outset of the programme, enabling the LDC to offer more bespoke, and directed, student support. In particular, the combined measures implemented led to significant improvement in grade-attainment (defined as an increase of individual student marks by one grade or more) of over 84% and 70% of students with non-traditional entry qualifications in Cohorts E and F, respectively, in comparison to only 21% (Cohort C) and 36% (Cohorts D). Numerous individual success stories of student attainment were also highlighted, which is a reliable indicator of successful implementation of our learning support intervention. For example, one student scored 9.43% in their diagnostic test and went on to gain an overall module score of 58.60%. This particular student interacted with the LDC an additional four times during their first term studying mathematics. Another student, scoring 20.75% on the diagnostic test, gained a final module score of 49.53%, and another student increased their score from 35.85% on the diagnostic test to an overall module score of 92.28%. Another benefit of

the diagnostic test was that it allowed the students to identify their own areas of weakness and were then more pro-active in seeking support, with those students scoring less than 40% on the diagnostic test visiting the LDC for mathematics support, on average, twice as often as those who scored above 40%.

Student satisfaction with communication and mathematics interventions

As described in this case study, our WBL student support mechanisms have developed over the years to a more robust practice, with early identification of students requiring more learning support, highlighting of specific areas of cohort weakness and developing learning support that is more directly targeted towards mitigating these identified gaps.

Although our interventions appear to impact student attainment, it was also important to confirm student satisfaction, so the 2018/19 students (Cohorts D and E) were asked to complete a short questionnaire related to their experience of the LDC support sessions throughout their time at University. The 2018/19 Year Two students (Cohort D) survey showed that just above 70% of the cohorts were of the opinion that the 'Studying Skills' and 'Exam Revision' sessions helped them with their general study approach on the course. When asked on their opinion of the 'Technical Report Writing' session, just above 80% of Cohort D were of the opinion that this helped them with their final project report-writing and just under 80% of them thought the 'How to give a Technical Presentation' session helped them with their interim-stage and viva presentations.

When asked their opinion on benefits of the Maths 'Exams Skills' support session, approximately 80% of both Cohorts D and E strongly agreed or agreed that this session helped them with exam success. When questioned on the relevance of mathematics support sessions, Cohort E found them more useful, with just above 70% of them agreeing these sessions helped them with the Year One Maths module assessments, dropping to 50% for the Year Two Maths module assignment for Cohort D.

Initially, maths support was provided on a voluntary basis, which then became mandatory attendance of sessions/workshops, as requested by employers. Another driving force behind this change was the requirement for sufficient student attendance to warrant the LDC time, who are a central University support mechanism. Although the recent change to compulsory attendance currently appears to be beneficial, with Cohort E module grade-attainment increased to 72.7%, compared to 53.9% for Cohort D, and pass rates staying static, open comments on survey results revealed student satisfaction has been impacted by compulsory attendance, particularly for individuals with past STEM qualifications and/or degrees. To mitigate this, we are currently evaluating methods for linking compulsory attendance of LDC mathematics support sessions to student grade-attainment in the module assessment elements, i.e. performance in the diagnostic screening and subsequent Class Tests. This aligns with the 'emergent nature of learning' approach, which is flexible and responsive to each learner's needs (McWilliams & Allan, 2014), with this proposition of adapted support having backing from our third stakeholder, the employers, who appreciate the merit of an approach that aims to provide targeted learning support to those in most need.

Evaluation and limitations

While some HEIs have developed pedagogical approaches that work well, the HE sector as a whole, is still exploring 'what works well in practice' for WBL/DA degrees. Most HEIs past-experience is in developing and delivering an educational experience tailored to offering 'for-employment' education, rather than an educational experience designed to offer 'in-employment' education and training (Stephens et al., 2014).

For WBL/DA programmes to be successful in curriculum design and delivery, the more complex, tri-partite student-employer-HEI relationship needs to be carefully navigated. HEI's successfully delivering WBL/DA programmes have developed partnerships with students and their employers, to ensure their HE academic teams effectively cultivate the key attributes of all their WBL/DA students, to minimise impact on learning attainment (Nixon et al., 2006; Tierney & Slack, 2005).

This case study, describes an ongoing intervention strategy, implemented in response to decreasing student grades, pass rates and both employer and student satisfaction. Although this intervention strategy was tailored to support our WBL/DA students, the challenges described within the case study are pertinent to all student cohorts that have a diversity of learners in relation to prior HE experience, qualifications, age, mode of study and commitments that affect HE study.

Our methodologies have now led to a point where we can discern markedly improved student grade-attainment and pass rates, and overall student satisfaction. One of the most significant findings from the implementation of our intervention strategy was that increasingly tailoring and contextualising the learning support from the LDC into the WBL Foundation Degree programmes in both mathematics and overall communication skills have led to significant increases in both WBL student engagement and attainment, as well as satisfaction. This confirms the importance of integrating skills within the discipline (Allan & Clarke, 2007; McWilliams & Allan, 2014) and that sessions explicitly focusing on learning development (such as communication and maths) can have value for Engineering students' development of transferable skills, as they provide opportunities for practice and to develop their self-awareness and confidence.

This case study has some limitations. These interventions were conducted at one UK University and the outcome of the interventions focused on one particular WBL programme. However, the development and implementation of the two intervention strategies was informed by international pedagogic research on supporting part-time and mature students, and cohorts undertaking blended/distance learning. Furthermore, the attainment issues detailed within this study are reflective of current issues in HEI, regardless of location and mode of study.

With a focus on attainment and engagement in the case study, it is more difficult to capture how our support interventions have positively impacted students' self-efficacy and self-confidence, which are areas of particular concern for part-time and mature learners (Tierney & Slack, 2005; Jameson & Fusco, 2014). Furthermore, it is difficult to ascertain to what extent module marks may have also been impacted by the contribution of other factors relating to the supervision and support by the module team.

Despite these limitations, the overall finding that implementation of intervention strategies tailored to specific cohort needs can lead to marked enhanced student

engagement, attainment and satisfaction confirms the importance of integrating skills, within programmes, that aid students to develop awareness of their own academic limitations and to contextualise their required learning support.

Disclosure statement

No potential conflict of interest was reported by the authors.

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