DEVELOPING LOGBOOK KEEPING AS A PROFESSIONAL SKILL THROUGH CDIO PROJECTS

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ABSTRACT

Deliberate practice, including focused practice time by students, feedback from experts, mentors, educators or peers, and student reflection (Nandagopal & Ericsson 2012) is needed in order to develop and excel in any skill. This study looks at whether deliberate and directed practice can be used to develop professional engineering skills in a CDIO teaching setting, using logbook keeping as a key example. A longitudinal analysis of logbook performance over year 1 and 2 for a graduating cohort (n = 76) was carried out. A questionnaire was given to the same cohort at the end of their final year projects to gauge logbook use during final year where no assessment was associated (36 responses). The analysis showed an improvement in logbook performance in year 1 from the first and second project, however a considerable drop in performance was noted at the start of year 2. Performance then significantly improved at the end of year 2 (ANOVA, $p = 0.05$). Furthermore all respondents maintained a logbook during final year although only 7 submitted their logbooks for this study. The results highlighted students maintained logbook use in final year, reflecting the positive effect of regular practice from year 1 and 2. However the drop in performance in year two may be due to lack of practice over the vacation and a discrepancy between higher performance required in year 2 and student expectations, which will be investigated further.

KEYWORDS

Projects, Skills, Standards: 3, 5, 7, 8, 10, 11, 12

BACKGROUND

Adopting the CDIO framework (Conceive-Design-Implement-Operate) at Aston has allowed for the development of professional skills while applying technical theory in team-based projects. However practice alone has little correlation to improving performance and skills competence. Whereas **deliberate practice**, i.e. practice with "deliberate effort" with the aim of improving competence and performance**,** has been shown to be effective in both (Ericcson et al. 1993; Nandagopal & Ericsson 2012). It is through deliberate practice that expertise can be developed. The ingredients for deliberate practice to occur include carrying out well-defined tasks, regular solitary practice, regular expert feedback, peer feedback and self-reflection of performance (Ericcson et al. 1993).

The skill of logbook keeping in the engineering profession is essential for documenting knowledge, primary data and technical detail that would otherwise not be captured through official company reports and other documentation (McAlpine et al. 2006). It also acts as a legal document for intellectual property protection and a key tool for project development and progress. With logbooks being an essential knowledge source of any engineering project, the habit of logbook keeping should not be underestimated. As a professional skill, logbook keeping lends itself well to being developed through regular deliberate practice.

At Aston, four major 12-week-long projects are delivered over the first two years of study on the mechanical engineering degree programs. With each project addressing different learning objectives, all share common threads in the application and development of professional and technical skills, such as logbook keeping, team working and problem solving. It is expected that with this regular repetition and formative feedback, students are engaging in deliberate practice and thus the expectation is that personal performance will improve over time. It is also expected that these skills will be utilised in future projects without explicitly setting assessments.

The hypothesis for this study is the repeated practice of keeping a logbook and feed forward assessment throughout the degree will result in retention of logbook keeping skills and an independently adopted practice of logbook use during student's Final Year Projects (FYPs), despite the lack of associated FYP logbook assessment.

AIM AND OBJECTIVES

The aim is to analyse whether assessed logbook taking from the four project modules effectively engage the students in deliberate practice and therefore develop this professional skill into their final year projects.

METHODS

Longitudinal Analysis of Previous Academic Performance

Longitudinal analyses of logbook performance and degree classification were carried out on all students who graduated in 2016-17. In the current curriculum mechanical engineering students are introduced to logbook keeping from week 1. Thereafter students are assessed with formative feedback on their logbook keeping skills throughout years 1 and 2 in a total of four CDIO projects. The logbook assessments were similar for all four CDIO projects and follows a marking matrix that reflected the requirements of the logbooks, that is: legible entries of work-in-progress, sufficient technical detail of project, project planning and weekly self-reflection of own learning (back of logbook). The relevance of logbook keeping and learning outcomes of the logbooks were covered in a short mini-lecture at the start of every project. The self-reflection element was taught using the "What? So What? Now what?" approach with exemplars.

The logbooks were marked against the rubric developed previously by academics using the CDIO framework and industry experience as a guide. The rubric was further developed using student feedback to improve the assessment and student engagement (Leslie & Gorman 2016). As well as the rubric, formative feedback was given where assessors were encouraged to use a form of the "What^2, How, Why" feedback model (Table 1 and 2). The

What^2, How, Why model allows for consistent feedback across assessors and outlines to the students: what went well, what could be improved, how the improvements could be made and why it is important. The logbooks were marked by three assessors moderated with two other assessors per project where

Two changes were implemented to the year 2 logbook assessments that must be noted: firstly, the students were told that a higher quality and performance was expected in the logbooks for year 2. This was to set a higher expectation that aligns to higher quality of work for year 2 engineering students. Secondly, the final logbook assessment (year 2, semester 2) required the inclusion of an item that was not explicitly stated but implicitly expected base on the mark scheme. The item was assessing if students used their logbooks to document test outcomes from their final product performance at the end of the module. An ANOVA test was carried out to analyse trends between logbook performances over year 1 and 2 and academic performance. The ANOVA test was chosen over using several paired t-tests to avoid increasing statistical type I error.

Table 1. Logbook assessment matrix in year 1 with What^2 How Why feedback model

	Perfect	**Very Good**	**Good**	**Poor**	**Unsatisfactory**	**Unavailable**
Record of all appropriate work done (including group meetings, research, designs, planning etc.) in appropriate logbook (i.e. hardback) for weeks 3-11 (MAX 10)	*[Logbook entries for all appropriate occasions & in appropriate book]*	*[Logbook entries for nearly all appropriate occasions & in appropriate book]*	*[Logbook entries for most appropriate occasions & in appropriate book]*	*[Logbook entries for some appropriate occasions OR in an inappropriate book]*	*[Logbook entries for few appropriate occasions AND in an inappropriate book]*	*[No logbook entries for any weeks regardless of book]*
Legible writing (pen not pencil) and consistent, logical layout, with dates & signatures including over any adhered inserts, mistakes crossed out not torn out or tipexed (MAX 10)	*[All legible, dated, signed + good layout]*	*[Nearly all legible, dated, signed + good layout]*	*[Mostly legible, dated, signed + reasonable layout]*	*[Areas that are illegible, mostly dated, signed &/or poor layout] layout]*	*[Mostly illegible, lack of dates & signatures, poor layout]*	*[All illegible, poor layout, no dates & signatures]*
Appropriate & easily understood drawings (sketches/technical) with sufficient detail e.g. clear annotation/dimensions as appropriate (MAX 10)	*[All drawings appropriate & with sufficient detail]*	*[Nearly all drawings appropriate & with sufficient detail]*	*[Most drawings present, appropriate & with sufficient detail]*	*[Lack of appropriate drawings or with insufficient detail]*	*[Very few drawings, inappropriate with little/no detail]*	*[No drawings & no detail]*
Sufficient/appropriate detail in descriptions & explanations (MAX 20)	*[Poss. to re-create exactly what was done/thought]*	*[Enough detail to re-create most things]*	*[Enough detail to work out most of what was done]*	*[Insufficient detail to re-create most work]*	*[Small amounts of insufficient detail]*	*[No detail at all]*
Reflections – Thoughtfulness & quality for weeks 3-11 (back of logbooks). Paragraph per week answering What? So what? Now what? (MAX 20)	*[Personal thought & development evident for all weeks]*	*[Personal thought & development mostly evident for most weeks]*	*[Personal thought & development often evident for most weeks]*	*[Personal thought & development not evident or not present for many weeks]*	*[Personal thought & development not evident or not present for most weeks]*	*[Personal thought & development not evident or not present for all weeks]*
Penalty for late submission @ 5% per day.						**Days**
PASS/FAIL - Appropriate logbook, legible, well laid out, signed & dated						
Overall grade						

Additional Comments:
What went well:
What could be improved:
How it could be improved:
Why it is important:

Table 2. Logbook assessment matrix in year 2 with What[2] How Why feedback model

	Perfect	**Very Good**	**Good**	**Poor**	**Unsatisfactory**	**Unavailable**
Evidence of project planning, scheduling & meetings (20 marks max.)	*[Clear evidence for every week]*	*[Clear evidence for nearly every week]*	*[Clear evidence for most weeks]*	*[Clear evidence for some weeks or unclear for most weeks]*	*[Unclear evidence for some weeks only]*	*[No evidence of any planning]*
Clear, traceable and repeatable detail throughout (20 marks max.)	*[Poss. to re-create exactly what was done/thought]*	*[Enough detail to re-create most things]*	*[Enough detail to work out most of what was done]*	*[Insufficient detail to re-create most work]*	*[Small amounts of insufficient detail]*	*[No detail at all]*
Evidence of independent research, ideas & incorporation into the project (30 marks max.)	*[Clear evidence of process throughout]*	*[Clear evidence of process nearly throughout]*	*[Mostly clear evidence of process throughout or clear through most weeks]*	*[Unclear evidence of process or weeks missing]*	*[Unclear evidence of process throughout, most weeks missing]*	*[No evidence of process evident]*
Reflections – self-evaluation & areas/methods of professional and technical skills improvement – Thoughtfulness & quantity of entries for weeks 1-11 (in back of logbooks) (30 marks max.)	*[Useful reflections evident for all weeks]*	*[Useful reflections mostly evident for most weeks]*	*[Useful reflections often evident for most weeks]*	*[Useful reflections not evident or not present for many weeks]*	*[Useful reflections not evident or not present for most weeks]*	*[Useful reflections not evident or not present for all weeks]*
Penalty for late submission @ 5% per day.						**Days**
PASS/FAIL - Appropriate logbook, legible, well laid out, signed & dated						
Overall grade						
Additional Comments: What went well: What could be improved: How it could be improved: Why it is important:						

Final Year Questionnaires

A questionnaire was given to FYP students at the dissertation submission. The aim was to gauge self-awareness of project planning, logbook use and skills confidence retrospectively. The questionnaire design has been discussed in a previous paper (Junaid et al. *under review*). Only the logbook keeping elements of the questionnaire will be discussed here.

One of the questions on logbook use provided a list as a multiple-choice question. The list of possible uses was collated from a previous study where students were asked to elaborate on how they used their logbooks (Junaid et al. *under review*).

RESULTS

Final Year Questionnaires

Thirty-six final year students completed the questionnaire (43 % of the cohort). All respondents had used their logbooks for project planning (100 %). The lowest uses were for documenting the build (75 %) and experimental design/protocol (76 %) (Figure 1). However, only 7 students submitted their logbooks for assessment. These logbooks had an average performance of 55.5 ± 10.3 %, which were lower than their previous individual performances.

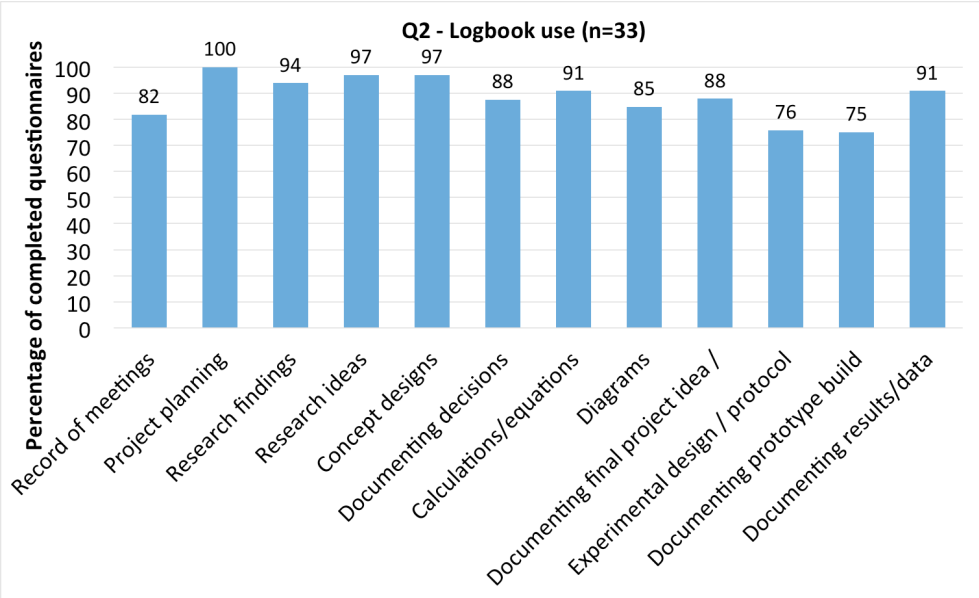

Figure 1. Logbook use at end of project (Questionnaire) showing 75-100% use.

Longitudinal Analysis of Previous Academic Performance

Longitudinal analysis of logbook performance (n = 76) showed year 1 logbook assessments marginally increased between term 1 and 2. After the six-month vacation period a considerable drop in performance at the start of year 2 was observed. Thereafter a significant improvement during year 2 was found ($p = 0.05$) (Figure 2). When split into final degree classifications, all student groups showed similar trends with most improvement seen in the Third class group (Figure 3).

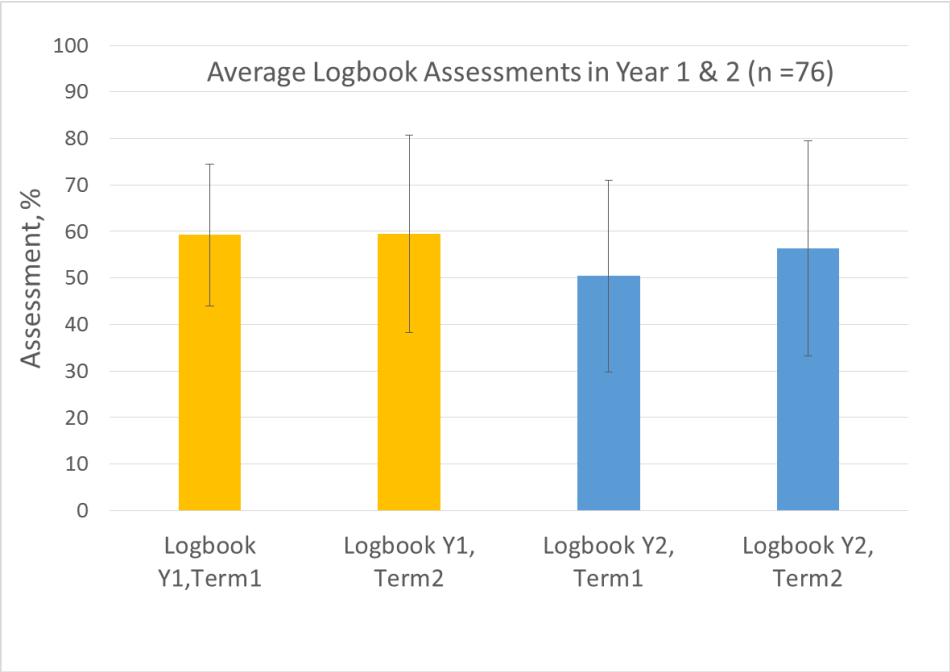

Figure 2. Average logbook performance in year 1 (yellow) and year 2 (blue) showed a significant drop in year 2, term 1, which was improved in term 2 (p = 0.05) (n = 76).

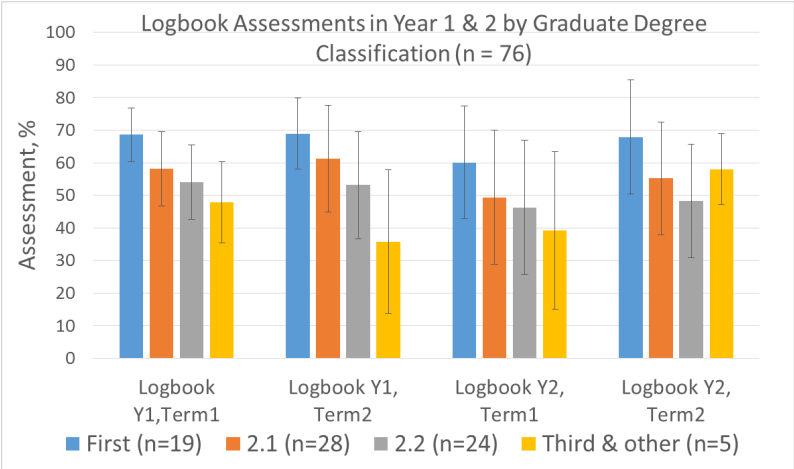

Figure 3. Logbook performances over year 1 and 2 according to degree classification showing greater improvements between assessments from Third class students (n = 76).

Year 1 and 2 Logbook Marks

Average year 1 logbook assessments showed a marginal increase in performance between term 1 and 2 (Figure 2). However, a drop in performance at the start of year 2 was observed, and a significant improvement in year 2 second term was found (p = 0.05).

Final Year Logbooks

Only 7 out of 76 students submitted their FY logbooks for the purpose of this study (9 %). Logbook assessment for these 7 logbooks had an average result of 55.5 ± 10.3 %, which

was lower than their previous assessments. The same logbook assessment was used as Table 2 with the omission of the self-reflection component.

When comparing the difference in performance from the first logbook assessment (year 1, term 1) to their last logbook assessments (year 2, term 2), the students who had submitted a FY logbook had improved their performance overall by 4.1 ± 23.5 % compared to a drop of -3.3 ± 19.9 % for those who did not submit (Figure 4), although this result was not significant.

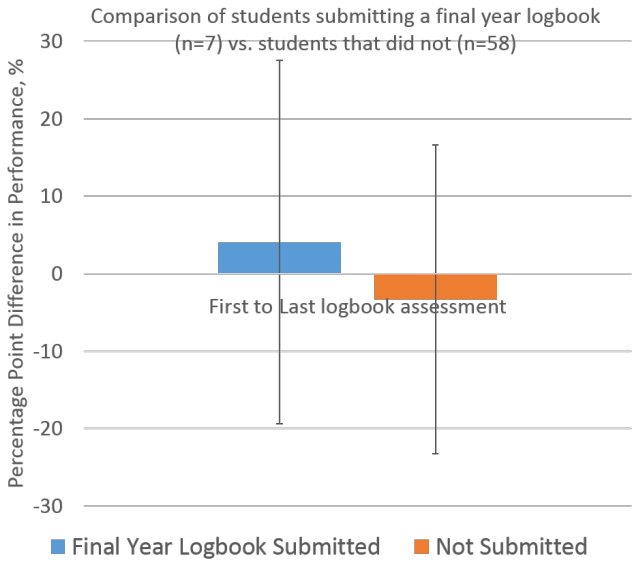

Figure 4. Students who submitted a FY logbook showed overall logbook improvements over year 1 and 2 compared to those that did not.

DISCUSSION

The analysis suggests high retention of logbook keeping in FYPs with 100 % of students using their logbook for project planning. The lowest documented logbook use was for prototype build (75 %) and experimental design/protocol (76 %), which was in part due to some projects being theory or analytical-based. However, logbook performance was lower in FY than in year 1 and 2. Accounting for degree classification, higher performing students did better in logbook keeping, however their performance did not increase or decrease significantly between assessments. The lowest performing students appeared to benefit most from deliberate practice, showing the greatest improvement. Areas that need to be addressed include lack of practice over vacation periods, motivations and engagement.

In general the longitudinal data of logbook performance over year 1 and 2 showed a pattern of improvement in each year but no positive trend over the 2 years, regardless of degree performance. In fact the significant drop in performance between year 1 and 2 reflects the lack of practice between the end of first year term 2 and start of the second year term due to the vacation period (approximately 6 months). This was consistent across high and low performing students. This may well be the primary missing element in implementing deliberate practice (Nandagopal & Ericsson 2012). Furthermore there may also be a discrepancy between higher performance required in year 2 and student expectations, which would be a compounding factor to the outcomes and will need to be investigated further.

The deliberate practice exercise does appear to be successful in continuing note keeping, as students continued in their FY projects. However, it does not appear to be successful in following good practice and maintaining good performance. It should be noted that this is based on a small number of submissions (n = 7). It appears some students are not practicing with a deliberate effort to improve although other compounding factors such as the step up in performance expected from second year engineering students must be investigated. Further improvement to the implementation of deliberate practice in logbook keeping is required such as putting more emphasis on the use of formative feedback from previous assessments to improve the next logbook assessment. It is also clear that students prioritise assessed tasks and therefore neglect useful practices that will aid their learning and performance but that do not hold any assessment, as is the case with logbook keeping in final year projects.

In this study, logbook keeping is considered a skill to be developed in itself and a valuable skill that can be taken into any engineering or technical industry (McAlpine et al. 2006). Although the relevance to industry is evident, the practice of logbook keeping was considered mundane to some students, who treated it as a means to an end (to achieve a good module mark) rather than a skill to develop and hone. Furthermore there were cases where logbook keeping was not used as designed, a work-in-progress document, but rather was retrospectively filled at the end of the week to ensure neat and presentable work for assessment. The problem of fixating on assessments is a universal issue shared across degrees. However, assessment is one of the key drivers to performance.

The element of self-reflection is also another skill that develops self-awareness, which is also being practiced in this study but rather underdeveloped. Indeed the breakdown of logbook assessment data (not presented here) showed the lowest performance in year 2 on average was in self-reflection. Despite addressing the importance of self-reflection at the start of every project and working through examples, improvement in self-reflection was modest. An interactive exercise using Kolb's cycle of learning (Kolb 1984) could be one example of developing a deeper understanding and therefore help in improving this skill.

There are several drawbacks in the study that should be noted. Firstly although a similar assessment matrix was used throughout the two years, there were minor adjustments to the assessments based on the module delivery and different teaching staff. Secondly the expectations in logbook quality and performance were raised after every iteration to reflect the competence expected at the education level taught. Finally further longitudinal analysis of the outcomes in individual performances should be carried out. This will reveal more accurately logbook performance patterns over the projects, however the analysis was beyond the scope of this paper.

CONCLUSION

Applying **deliberate practice** to logbook keeping has been effective to some extent. The highest performance was found in year 1, term 2, however a drop in performance was improved in the final CDIO project in year 2, term 2. It is hypothesised that extended periods of no practice, in this case several months, may be an important factor that negatively affects performance and therefore should be addressed. It is also predicted that the drop in performance was a reflection of setting higher expectations and a tougher marking scheme at the start of year 2 despite the assessment matrix remaining similar throughout. In the individual final year projects, all questionnaire respondents had used a logbook in some form, however performance on non-assessed logbooks showed a drop compared to year 2

assessed logbooks. The variation in logbook performance across the board will need to be investigated further for improvement. Factors such as interest, engagement, extended periods of no practice and student expectations should be investigated to improve performance. Furthermore, the emphasis of deliberate practice must be tempered with focussing on areas of improvement and engaging students with formative feedback from previous assessments.

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BIOGRAPHICAL INFORMATION

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