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Advancing Fidelity and Feedback in Practical Activities with Formative Sprints

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CONTEXT
The University of Technology Sydney (UTS) has encouraged the transition to studio-based learning to promote the integration and development of technical and professional skills within project-based contexts. Formative sprint deliverables (opportunities for students to present their progress and receive feedback to make improvements) are used to help students engage with feedback through attempting design exercises to create artefacts that are submitted within their final portfolio assessment. The studio is an opportunity for students to draft, receive feedback, reflect and improve their work and apply the theoretical knowledge they have learned from previous subjects to a real-world engineering challenge.

PURPOSE OR GOAL
This paper reports on the interventions within a mechanical and mechatronic engineering studio to support students' feedback literacy as a first stage of a larger study. The investigation explores students' ability to engage with and use the feedback from the formative sprints to take action to demonstrate higher learning improvement in their final portfolio. It also introduces some of the dialogical feedback approaches implemented to further engage students with feedback.

APPROACH OR METHODOLOGY/METHODS
The assessment criteria for the student portfolio includes a focus on students' improving their project artefacts by reflecting on and using the feedback given in the formative sprints to take action. To understand student's critical engagement with the sprint feedback, student's responses to and use of feedback were characterised based on instructor observations of how they engaged with formative exercises and reflected in their engineering design journals.

ACTUAL OR ANTICIPATED OUTCOMES
Observations found that higher achieving students demonstrated the ability to reflect on and use the feedback they had received (exhibited a high level of feedback literacy) which was also demonstrated in the higher achievement in their portfolios grades and rubric feedback score. The students' journals highlight that high-achieving students demonstrated feedback literacy by critically engaging with and responding to feedback they received to take action in a manner described by the feedback literacy framework proposed by Carless and Boud (2018).

CONCLUSIONS/RECOMMENDATIONS/SUMMARY
The findings highlight that the ability to respond positively to use feedback to take action has an impact on students' level of demonstrated achievement reported in their portfolio being reflected in higher grades. From a learning perspective, the findings support the importance of improving student's feedback literacy and students using the feedback they receive to take action.

KEYWORDS

Feedback Literacy, Authentic Assessments, Assessment Fidelity

Introduction

Engineering graduates need to be able to address complex challenges with creative solutions to keep up with industry and technology advancements. This was a primary motivator behind the work of renewing the mechanical and mechatronics engineering programs at the University of Technology Sydney (Hadgraft et al. 2019, 2016).

Mechanical Design Fundamentals Studio 1 (MDFS1) is the first studio subject for mechanical and mechatronic engineering students in the first semester of their second year. The subject runs in Spring with a smaller cohort of 130-150 students, and in Autumn with approximately 260 students. Students work in teams to design and build a robot to achieve the goals of the Warman Design and Build Challenge (Warman, 2024). There are an infinite number of solutions for students to tackle this task which require them to use their judgment to manage the multiple possibilities and competing demands. The subject provides students with an opportunity to develop their skills in managing complexity by following the design process to undertake testing, critical evaluation, and reasoning to arrive at their proposed solution (Willey and Machet 2018, 2019, Machet et al, 2021).

The learning is organised so that students have ample opportunities to demonstrate how technically proficient they are at individually designing components and how they work as a team to bring these components together to produce a (working) design. The subject is divided into 4 sprints, each three-weeks in length, covering the 12-week semester. The sprints provide an opportunity for students to present their progress and receive feedback to make improvements to their work moving forward. Students are guided between the sprints via individual Design Exercises (DE) and team based Design Reviews (DR), that are submitted at the end of each sprint. The design exercises help students in creating individual artefacts that inform their personal portfolios and the creation of components that are needed for the team to design and build their systems. The design reviews are an opportunity for teams to present their design process and progress with the complete system. Design exercises and design reviews are interdependent activities to foster teamwork and enhance the individual and collective output of students and develop their understanding.

In Lidfors Lindqvist et al (2023) the correlation between formative sprint deliverables in the form of design exercises and students' final grades was presented. The formative nature of the sprints increased assessment fidelity (Sadler, 2010), whilst also being effective in developing feedback literacy by promoting student engagement, reflection and use of feedback for improvement of their work (Carless and Boud, 2018). Carless and Boud (2018, p.1315) describe Feedback Literacy as "the understanding, capacity and dispositions needed to make sense of feedback and use it to enhance one's work and learning" including using feedback to take action. The formative design sprints in Mechanical Design Fundamentals Studio 1 are structured to help students develop their judgment, feedback skills and encouraging dialogic feedback. Carless (2012) defines dialogic feedback as the interactions of sharing explanations, negotiation of meanings, and clarification of expectations. This process suggests overcoming some of the traditional problems of feedback processes within higher education where previous studies have found that some of the issues related to feedback being received too late for students to improve (Higgins, Hartley, & Skelton, 2001), students are not able to understand the feedback (Falchikov, 1995, Weaver, 2006) or students are not able to act based on the feedback they received (Poulos and Mahony, 2008). The formative sprints provide regular feedback cycles which facilitates the continuous dialogue between students developing their comparative judgement and supporting them to use the feedback to improve their work.

In this paper, we expand on the findings from Lidfors Lindqvist et al (2023), which indicated that the student's contribution in the formative sprints and the ability to respond positively to feedback has a significant impact on a student's ability to achieve a higher grade, by further exploring how the students within the different grades engage with feedback within the sprints. We also present some of the interventions and changes that were made to improve the intended outcomes, based on previous findings, observations, and student feedback.

Structure of Mechanical Design Fundamentals 1 Deliverables

The delivery of the learning experience is informed by the close connection between Faculty of Engineering and IT (FEIT) Graduate attributes and subject learning objectives. In this way, the focus is on students having opportunities to enhance their professional skills together with their technical capabilities by engaging with non-graded sprints and focus on feedback. A performance-based rubric is used to grade the final portfolio. The rubric was designed with descriptors for students' performance in the EDJ, Persona and Artefacts. Whilst the Design Exercises present a more detailed description of the requirements for those artifacts. To achieve a specific grade, students must include all the required items and meet the performance level requirements. In Figure 1 the deliverables show how each submission item contributes to the development of their portfolio. The students are positioned as project experts and the teaching team as their advisors.

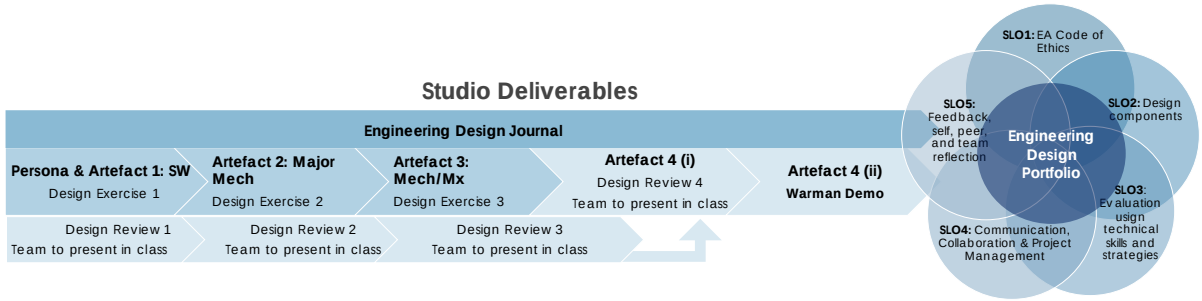

Figure 1. Studio deliverables, showing the details of sprint submission and their role in the certation of the portfolio.

To better understand the deliverables, the following components were required to be submitted by students to complete their Engineering Design Portfolio (EDP):

1. **Professional Persona:** including the student's name, discipline, and aspiration in the engineering industry and experience in the Mechanical Design Fundamental Studio 1.
2. **Engineering Design Journal (EDJ):** includes details on the student's individual learning journey, reflection and feedback from throughout the semester. This is to be submitted as a separate document for each sprint and in the final submission.
3. **Four (4) artefacts**
   a. **Artefact 1 (SolidWorks Design):** This activity requires students to demonstrate their attention to detail, accuracy in following given design specifications, and ability to use SolidWorks tools and AS1100 effectively. Details are presented in the form of Design Exercise 1 (DE1) and due at the end of Sprint 1.
   b. **Artefact 2 (Major Mechanical):** Informed by the team's design, students report their individual work on a major mechanical component includes further ideation, SolidWorks modelling, manufacture-ready drawings to AS1100 standards, prototyping, testing and evaluation implementation to the final system. This learning process is supported by Design Exercise 2 (DE2), the teams design decisions, EDJ entries and is due at the end of Sprint 2.
   c. **Artefact 3 (Mechanical or Mechatronics):** Similar to artefact 2, this artefact supports team's robot development. In communication with studio mentors' students undertake similar processes to define the mechanical or mechatronics problem they want to solve. This learning process is supported by Design Exercise 3 (DE3), the teams design decision, and the EDJ entries. This artefact is due at end of Sprint 3.
   d. **Artefact 4:** This is the evaluation of the team's design process, build, performance and project management.

During the semester, teams are expected to participate in Design Review sessions held in class in the last week of each sprint (weeks 3, 6, 9, and 12). Teams present their design process for a

panel consisting of academics, tutors and/or industry professionals. The final Design Review in week 12 requires the implementation of feedback from all three preceding design reviews and serves as evidence of the team's contribution to the whole-of-project. The performance of the system's ability to achieve the task will be evaluated via a demonstration in week #1 of the assessment period. Students produce their own record of individual contributions throughout the semester via the EDJ, and a project evaluation in the Final Engineering Portfolio submission. This learning process is supported by guidelines given for the Design Reviews, and the EDJ entries. Submitted at end of Sprint 4 and Demonstrated during the Assessment Period.

Methodology

The final portfolio marking rubric used in both semesters in 2023 considers student's ability to improve artefacts based on the feedback given in the design exercises as per Table 1. The final grade for the portfolio and feedback score from the rubric were then used to investigate the correlation between the improvement in work and the application of the provided feedback during the marking process. The learning improvements from each sprint were investigated by looking at grades in DE1, DE2, and DE3 and to allocate the feedback score during marking. The portfolio was marked out of 100 points with the feedback score ranging from 0 to 2.5 as per Table 1. Based on data from the marking process the an average feedback scores of 5 submissions calculated and plotted against the portfolio letter grade.

Table 1. Feedback item in rubric for the portfolio submission provided to students

0 pts Not Yet Novice	1 to >0 pts Novice	1.5 to >1 pts Proficient	2.5 to >1.5 pts Expert
Artifacts are not improved based on feedback received. E.g., due to not submitting design exercises for feedback.	Some effort is made to improve artifacts based on feedback, but not all suggestions are implemented.	Most suggestions for improvements are implemented, resulting in improved artifacts.	All feedback is carefully considered and implemented, resulting in significantly improved artifacts.

To understand students' engagement with the studio across the different sprints and portfolio grades, it is important to reflect on the patterns and trends. As part of the process of giving feedback in each sprint and marking the final portfolio reflective observations are made to make sure there is a consistent quality of the feedback provided by markers, with the intention of using them to evaluate the effectiveness of the learning interventions and improve future offerings of the subject.

Results

Students Ability to Use Feedback Impact on Portfolio Grades

From these rubric scores, it was noted that the high-achieving students were more likely to use the feedback they received to improve their work. This was something that could be noted from their achievements in both the Design Exercises and the portfolio as supported by findings in Lidfors Lindqvist et al. (2023). As students' grades increase, so does the feedback score given in the rubric. This indicates that student's demonstrated use of feedback was an indicative predictor of the grade received in their final portfolio, highlighting the importance of feedback literacy (that is understanding and using feedback to take action).

In figure 2 the graph suggests that there is a strong linear trend between the feedback score received and the grade received in the portfolio. This means that high achieving students are more likely to improve their work according to feedback.

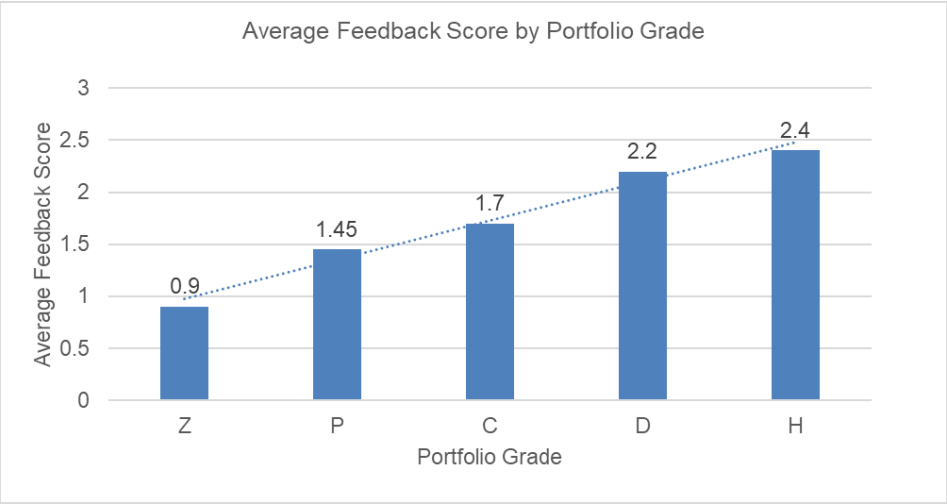

Figure 2. The average feedback score plotted against the grade.

Considering Pearson correlation coefficient for normally distributed data shows a significant positive correlation between portfolio grades and feedback scores ($P<0.0001$, $r=0.85$, $N=25$). This supports that students that achieve a higher grade in their portfolio are better at using the feedback provided to improve their portfolio submission.

Students' Characteristics Within Different Portfolio Grades

These observations provide a comprehensive understanding of students' development and feedback literacy. Table 2 shows the characteristics of students' responses to feedback at different grade levels. The observations of students' journals found that high-achieving students were feedback literate (or at least demonstrated their feedback literacy) being able to critically engage and respond to feedback via action in a manner described in the framework proposed by Carless and Boud (2018). However, students receiving lower grades demonstrated less evidence of using the elements of feedback literacy to improve their learning.

Table 2. Observed characteristics of students in different grade levels based on their ability to engage with feedback in formative sprint sprints.

Fail	Contains some generic reflections on work undertaken and limited or no consideration to feedback. No evidence of reflecting on how to improve according to the feedback provided by tutors or peers. Most have received comments to seek assistance in class throughout their design exercises but no evidence in their journals that feedback was reflected on or ever followed up. The students have then mainly provided a limited or reasonable attempt with areas lacking without actioning change from the feedback they had been provided.
Pass	Various levels of effort in properly completing the design exercises were made. Similarly, various levels to implement feedback into portfolio artifacts were made, which reflects on the feedback scores received. There are instances of limited reflection, generic attempts, missing key elements, and limited effort. Some were told to seek assistance in class and while some individuals actively sought feedback in class and recorded it in their journals, there was still a need for them to properly action the feedback they were given to improve the portfolio.
Credit	Mainly reasonable attempts in the design exercises, but some areas in the design exercises may have been lacking which result in detailed feedback. Most journals reflect on the feedback and the need to incorporate it better, but how well they action the feedback varies. Some feedback was actioned to improve the final portfolio however not all feedback or consistently. For example, feedback used for artifact 1 was not transferred to the new artifacts or some details were just ignored.
Distinction	Mostly reasonable attempts with feedback provided. Although feedback was not always incorporated between design exercises themselves when submitting the portfolio all/most of the key feedback had been considered. Some feedback was omitted still, which reflects on the feedback score. Most journals considered some level of relation to feedback, however mainly for the group part.
High Distinction	Students are feedback literate; they are able to incorporate and reflect on feedback extensively. Most either plan and/or reflect on changes made in correlation to the feedback they received. Most students also considered peer feedback and face-to-face advice and record this in their journals and evidently implement those changes in their portfolios. Almost all students had a section in the portfolio that considered feedback as reasons to change their designs.

Changes to the Studio Structure in 2024

Informed by faculty and student feedback, in Autumn 2024, the design review and demonstration were embedded into the portfolio as the fourth artefact and the portfolio was changed to contribute to 100% (compared to 70% in the previous semester) of the student's grade. The objective was to promote a focus on formative feedback, self-assessment and reflection to assist students to understand both what is required and to take action to work towards their desired grade. To achieve a specific grade, students must include all the required items and meet the performance level requirements outlined in the rubric. This was embedded as a map for students to track their own performance across the formative sprints. Students receive feedback and can evaluate their progress to guide discussions with their studio mentors. This feedback is intended to be used by students to improve their work iteratively. How feedback is applied is recorded at each opportunity as reflections in an Engineering Design Journal (EDJ).

Processes to Improve Class Engagement and Feedback

With the Autumn sessions, generally having a significantly larger cohort (~260 students) compared to Spring sessions, and with a projected growing number of students in the future, there was a

strategic change to have concurrent classes. In Autumn 2024, the cohort was spread across 8 classes, with 3 classes running concurrently in the morning and midday, and 2 classes running in the evening. The classes have different tutors with different levels of experience, and similarly, students working in different lab facilities meant they have different levels of support. The dialogic feedback (interactions of sharing explanations, negotiation of meanings, and clarification of expectations Carless (2012) was observed to mainly occur between the in-class tutor and students.

Hence, as an additional layer to the conversation students had with their instructors and peers in class, measures were taken to incorporate a feedback loop for co-creation, negotiation and setting student expectations. Willis et al (2021) found that digital feedback loops had a positive impact on both students and teaching staff. In our case, Microsoft Forms was primarily used to gather students' responses and feedback; whilst Microsoft Teams, Canvas (the subject Learning Management System (LMS)) and in-class presentations were used to close the feedback loop for students; reporting trends, observations and actions taken based on the responses by the cohort.

One intervention was the incorporation of an in-class activity Highlights, Lowlights and Aha-Moments which gives direct insight into students positive learning experience and potential blockers which the teaching team can address. The outcome of these are presented in class to help students reflect on others experiences, and create the link that the teaching team can take their feedback onboard and make change whilst the class is in action.

Another intervention was a closed-loop feedback form, allowing students to rate various statements on a Likert Scale ranging from 1 to 5 with a corresponding open-ended question to provide feedback on their experience with the feedback they received in the sprints. Digital technologies let teachers receive timely input from students, allowing them to make informed decisions to enhance the learning experience (Willis et al., 2021). The aim of the feedback form was to gather detailed insights into student satisfaction with the feedback provided and identify specific areas where our feedback could be improved. This approach is intended to enable instructors to understand the students' perspectives on whether the feedback was sufficient and meaningful to help them improve their performance in subsequent sprints. The open-ended question provided additional qualitative data to help us understand the reasons behind their ratings, offering deeper insights into their experiences and suggestions for improvement. This also allowed for adjustments in the benchmarking for markers.

Preliminary Observations of Student Achievement

The impact of the outlined Autumn 2024 improvements is currently being investigated with the results being published in a future paper. The changes have been specified to outline how we have responded to our observations, feedback and outcomes. However, an analysis of the subject results for Autumn and Spring semester 2023 and Autumn semester 2024 (figure 3) suggests the changes have been effective in helping or potentially motivating poorer students to demonstrate higher achievement, which can be observed by the redistribution of a percentage of students now achieving a credit instead of a passing grade. A Chi-Square statistic of 6.1128 with 2 degrees of freedom and resulting p-value of 0.0471, indicates that the observed difference in figure 3 is also statistically significant. This implies that changes made between 2023 and improvements in 2024 have impacted student learning achievement. The relationship, if any, between this improvement and an improvement in these students’ engagement with the elements of feedback literacy will be investigated further.

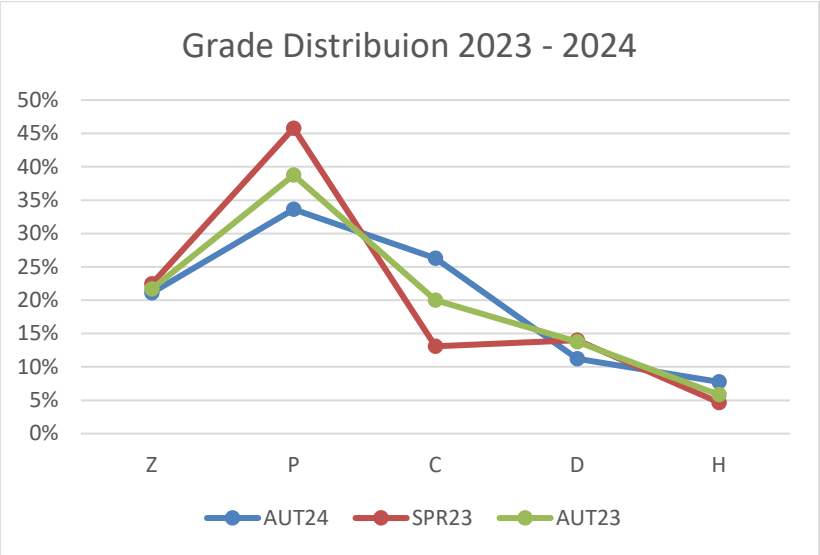

Figure 3. Grade distribution across Autumn 2023, Spring 2023 and Autumn 2024.

Discussion

External feedback that focuses on supporting students to refine their own internal feedback has more impact on learning than conventional feedback which is seen as “telling” according to McConlogue (2015). The formative design exercises are scaffolded as providing students with external feedback to refine their internal feedback. Looking at the characteristics of the higher-grade students, they show evidence of using external feedback to build on their own feedback and that they also seek other sources of feedback to take action. Students with lower grades did not actively demonstrate independently seeking feedback from secondary sources, whereas high-achieving students regularly sought feedback from mentors and peers.

The changes made for Autumn 2024 showed that there was a reduction in students achieving a pass and an increase in students receiving a credit. The results for high achieving students in the distinction and high distinction range have remained largely unchanged, which aligns with previous observations that high achieving students are already actively demonstrating their feedback literacy and hence were already using the feedback and seeking feedback from secondary sources to improve their work.

Students need to recognise the value of feedback and understand their active role in feedback processes to effectively use feedback to improve their work (Boud and Molloy, 2013). From the feedback score and the student characteristics, it was observed that students in the fail to pass (Z-P) range did not demonstrate the ability to engage with the feedback provided to take action. This resonates with Sadler (2010), that students are often not equipped to understand or act on feedback, so key messages remain invisible. The students in the Distinction to High Distinction (D-HD) range appear to understand and appreciate the feedback via self-reflection in their journals, was valuable. They also demonstrated using it to improve their work which is also evident through their feedback score. The combined observation of the feedback score and student characteristics further supports the suggestion in Lidfors Lindqvist et al (2023), that there is a probable correlation between students' final grade and their level of engagement with and use of feedback.

Students’ responses to feedback may be due to their individual characteristics or previous experience (Carless and Bound, 2018). This suggests that further consideration may need to be taken in the scaffolding and communication to students of the role of their feedback (Willey & Gardner, 2012), e.g. academics using studies like this, to provide evidence of the importance of the feedback to students and explain their role as active learners. Weaver (2006) suggests that students may need guidance in understanding and using feedback before engaging with it. Instructors are responsible for equipping students with strategies for taking productive action on

feedback information, conversely students carry responsibilities to engage with and use feedback (Nash and Winstone 2017, see scaffolding pg 640 Willey and Gardner 2012).

Conclusion

The studio subject described uses an active learning approach, based on student-cantered learning. Our aim is to provide learning environment for active student engagement, metacognitive development, and personalised learning experiences through flexible delivery methods, and the supportive role of mentors in facilitating learning. These elements collectively aim to promote higher-level learning outcomes among students. The observed student behaviour suggests that high-achieving students are successfully engaging with the feedback process, whilst lower-achieving students show less evidence of engagement. The extent to which this may result in their lack of success in the subject is currently under investigation. Future studies will investigate the potential of dialogic feedback processes to enhance assessment fidelity and promote students' engagement as active learners by improving their feedback literacy. Improvement is also anticipated through the requirement of dialogic feedback processes also requiring educators to improve their feedback techniques and strategies to enhance the dialogue with learners.

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