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# Engaging remote students in traditionally physical experiential learning environments (mechanical workshops)

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## CONTEXT

2020 saw many Universities transition learning activities from in person to online or remote delivery methods due to the COVID-19 pandemic, in semester 2 some classes returned to on-campus delivery. MECH1400 Mechanical Construction is a first-year unit of study that introduces students to the engineering design cycle, drawing and machining techniques through an experiential design and build project, utilising traditional mechanical engineering machining equipment such as lathes, mills, and hand tools. In semester 2 of 2020 students were offered the choice of attending on-campus classes or remote offerings, with 41 of 73 students choosing to study on campus (note some were overseas with effectively no choice).

## PURPOSE OR GOAL

The purpose of this study was to investigate whether online/remote delivery of learning activities can enable remote students to achieve equivalent learning outcomes as their on-campus peers, particularly as the unit is traditionally taught with experiential learning activities based around a mechanical workshop environment.

## APPROACH OR METHODOLOGY/METHODS

This study analysed and compared student results for assessment tasks for on-campus and remote students, plus other factors such as Canvas access rates and class attendance. Informal tutor feedback and end of semester institutional student satisfaction survey comments were examined to gain further insights.

## ACTUAL OR ANTICIPATED OUTCOMES

On-campus students had higher average marks for all assessment tasks (7.3% - 13.5%); despite remote students having an average of 29.8% more page views on Canvas.

End of semester student satisfaction surveys indicate that students prefer the physical workshop sessions to online tutorials and workshops, though limited comments were available.

Informal tutor feedback indicated that students were less engaged in the online learning activities, with some online students not attending their "virtual" workshop sessions, and online only tutorials having low attendance for both the online and physical cohorts.

## CONCLUSIONS/RECOMMENDATIONS/SUMMARY

Remote students achieved a final mark for the unit that was on average 9.9% lower than their on-campus peers, despite having a 29.8% higher Canvas access rate. Two conclusions are arrived at: The online learning activities need further development to help reduce or eliminate this difference for the 2021 student cohort and/or further investigation needs to be undertaken to establish why the online cohort are not better engaged with the online curriculum.



## KEYWORDS

Remote learning, experiential learning, student engagement

# Introduction and background

2020 saw many Universities transition learning activities from in person to online or remote delivery methods due to the COVID-19 pandemic. By the second half of the year opportunities to return to face-to-face classes existed for many Australian Universities, with the University of Sydney offering many units in both online and/or on-campus modes.

MECH1400 Mechanical Construction is a first-year Unit of Study (UoS) that introduces Mechanical Engineering students to the engineering design cycle, drawing and machining techniques through a predominantly hands-on design and build project, utilising traditional mechanical engineering machining equipment such as lathes, mills, and various hand tools. The unit discussed in this paper follows a previous semester unit (MECH1560) in which students were introduced to basic machining techniques and processes, utilising much of the same machining equipment. In 2020 classes were moved online in week 5 of semester 1, and consequently students undertaking MECH1400 in semester 2 generally had little or no experience with hands on machining.

Experiential (EL) and Problem Based Learning (PBL) can be effective tools for developing engineering knowledge and skills in a mechanical engineering workshop environment (Abellán-Nebot, 2020; Li et al., 2019; Malicky et al., 2010; Wood et al., 2005), improve students social connections and confidence in their learning (Bhute et al., 2021; Pamungkas et al., 2019), and should help achieve many of the learning outcomes for this introductory unit of study, particularly outcomes L02, L03 and L04 as listed below:

- **LO1**. apply statics, dynamics, and thermodynamics analysis methods to real design problems
- **LO2**. undertake a simple design and build project from conception to completion
- **LO3**. apply theory and analysis to real machinery, use of machine and hand tools
- **LO4**. demonstrate basic workshop skills, learning to use machine tools for production of complex parts
- **LO5**. undertake research into existing design as part of developing new design
- **LO6**. place the mechanical engineering profession in historical context
- **LO7**. use self-reflection and critical thinking to improve your learning skills.

Learning activities in this UoS revolve around a central PBL major design project, with groups designing and building a small reciprocating compressed air motor as a team of 3-4 students. 50% of the final marks for the unit are related to this project, as listed in Table 1. The material is delivered weekly via a 1-hour lecture, 1-hour tutorial and 3-hour workshop session.

**Table 1 Assessment Structure**

| Task | Weight | Group or Individual |
|---|---|---|
| Ass. 1 Steam engine historical research report | 20% | Individual |
| Ass. 2 Design proposal | 10% | Group |
| Ass. 3 Progress report | 15% | Group |
| Ass. 4 Final report | 15% | Group |
| Ass. 5 Project outcome | 10% | Group |
| Ass. 6 Reflection report | 10% | Individual |
| Ass. 7 Quiz | 20% | Individual |

Students start the unit with an individual research task related to the historical development of steam and air engines, the materials used, manufacturing processes, basic mechanics, and other considerations. The main group design project is introduced in week 3 and consists of 4 deliverables:

1. Design proposal report that provides background information, engineering analysis and material selection to determine component sizing, a machining resource plan and basic engineering drawings of the proposed design solution and a project plan.
2. Progress report provides summary of group progress, an updated Gantt chart, breakdown of required components to be manufactured and resources required, plus fully detailed orthogonal drawings following AS1100.
3. The final report includes elements of the previous reports, plus a reflection on group performance, and final drawings with the addition of an assembly drawing.
4. Project outcome (this is the only assessment task that differed for on-campus and remote students):
    a. On-campus – The students' air engines are tested and assessed for general machining quality, tolerances and surface finishes, aesthetics, and complexity. Devices are required to run for at least 1 minutes.
    b. Remote – Students submitted a Solidworks model that was required to demonstrate full kinematic functionality and theoretically be able to perform if machined. Students also presented a short talk outlining how their device works, why they designed it as they did etc.

The final two individual tasks are:

- Reflection quiz is a self-reflection written report with students' critically reflecting on two learning activities from the UoS, and how they intend to use those activities to improve their learning in the future.
- Quiz is a 48hr take home written task that assessed students' learning in the entire course, including tutorial and lecture material.

In semester 2 of 2020 students were offered the choice of attending on-campus classes or remote offerings, with 41 of 73 students choosing to study on campus. Of the 32 students that chose to not attend on campus classes, 22 were not in Australia (and unable to return).

The only assessment task that was modified for remote students was the final project outcome (Ass. 5), as they were not able to physical manufacture and test their device, and instead were required to virtually "construct" their device in Solidworks and then demonstrate kinematic functionality via a short talk and video demonstration.

# Purpose of study

The purpose of this study was to investigate whether online/remote delivery of learning activities can enable students to achieve equivalent learning outcomes as their on-campus peers; and whether remote students are less engaged in the unit, particularly as it is traditionally taught with experiential learning activities based around a mechanical workshop environment.

# Methodology

This study analysed and compared student results for assessment tasks for on-campus and remote students; plus, other factors such as: Canvas access rates, attendance workshop sessions (on-campus or online). Informal discussion during and after semester was held with tutors and end of semester student survey comments also examined to gain further insights.

## Assessment results

Students' assessment mark outcomes for all tasks were averaged for on-campus and remote students and the results presented with box and whisker plots, showing means and quartiles.

### Class attendance

Student attendance was recorded and collated for both on-campus and remote/online workshop sessions.

### Canvas access rates

Student use of Canvas was analysed and compared for on-campus and remote students

### Tutor feedback

Tutor feedback was sought informally throughout semester during regular meetings and at the end of semester.

### End of semester student survey

Student comments from the regular institutional end of semester student satisfaction survey were reviewed for comments of relevance.

## Results and discussion

### Student assessment task results

Figure 1 presents box plots of the mean marks (mean shown as X) for all assessment tasks, comparing remote and on-campus students, tasks are plotted left to right in the chronological order of completion. On-campus students achieved higher assessment marks for all tasks, ranging from 0.8% (Ass 5 - Project Outcome) to 13.5% (Ass 1 - Historical report and Ass 4 – Final Project Report), however it should be noted that significance tests were not performed. Of the tasks, the requirements were the same for all students except Ass 5 (which could henceforth be excluded from discussion).

Of particular interest is the first assignment – 'Historical Research Report', as it is due early in semester in week 3 and is not dependant on students having attended any workshop sessions; it could be expected that there would be no difference in marks for this task between the remote and on-campus cohorts. Similarly, assignment 6 is an individual written reflection assignment and it could be reasonably expected that this mark would not differ between the cohorts. Comparing tasks 2, 3 and 4 it can be observed that for both cohorts of students the mark increased, possibly as students used feedback effectively to improve the quality of their submitted drawings and written reports (groups were marked by the same tutor for the major project assignments).

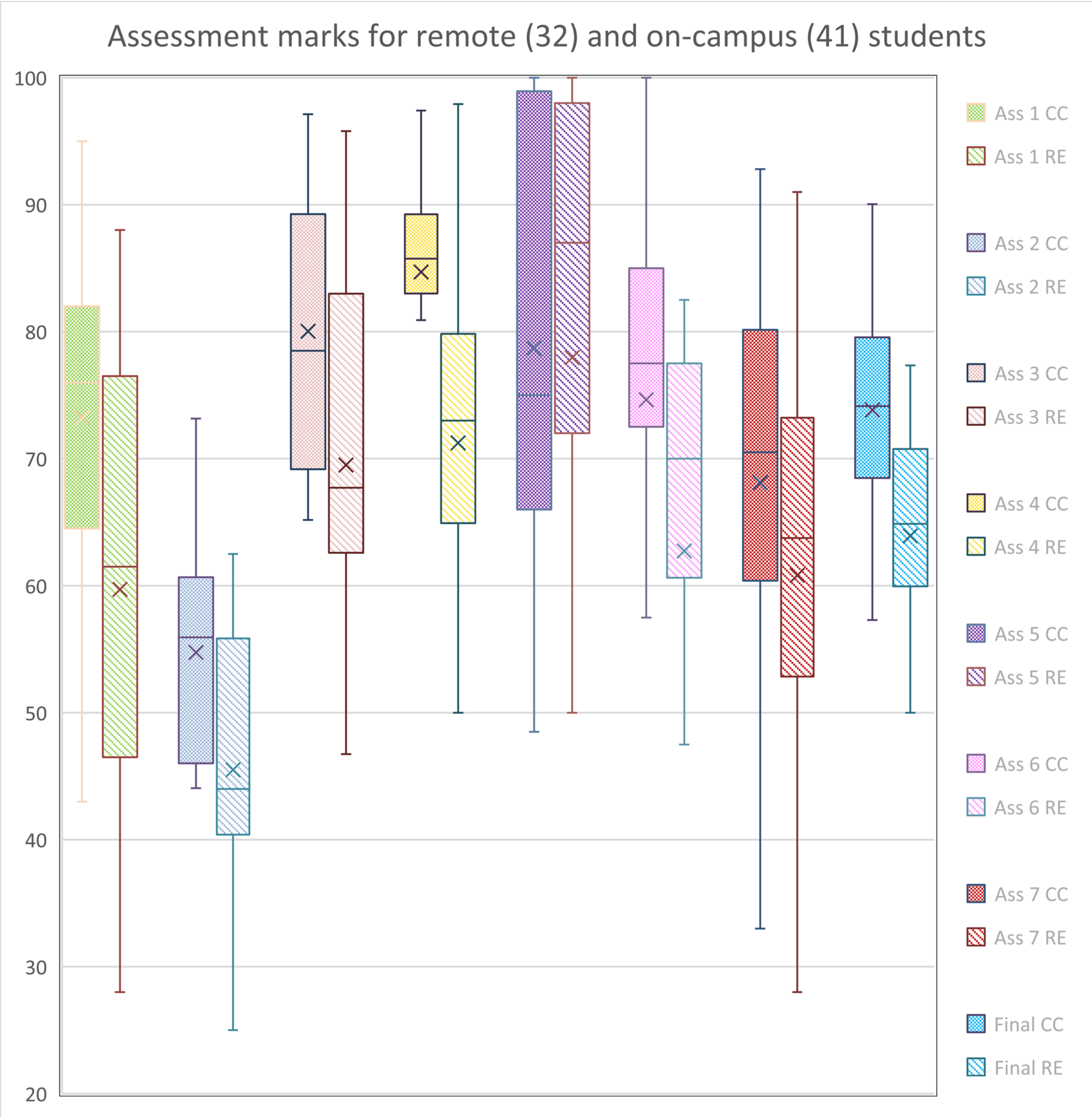


**Figure 1 Mark comparison for remote (RE) and on-campus (CC) students for all assessment tasks**

## Class attendance

Figure 2 summarises workshop session (dedicated for major project work) attendance for both student cohorts. Note that workshop sessions did not start for remote students until week 4; on-campus students were completing general workshop safety inductions and equipment training in weeks 2 and 3. It is apparent from the plots that remote student attendance is lower than on-campus attendance for every week.

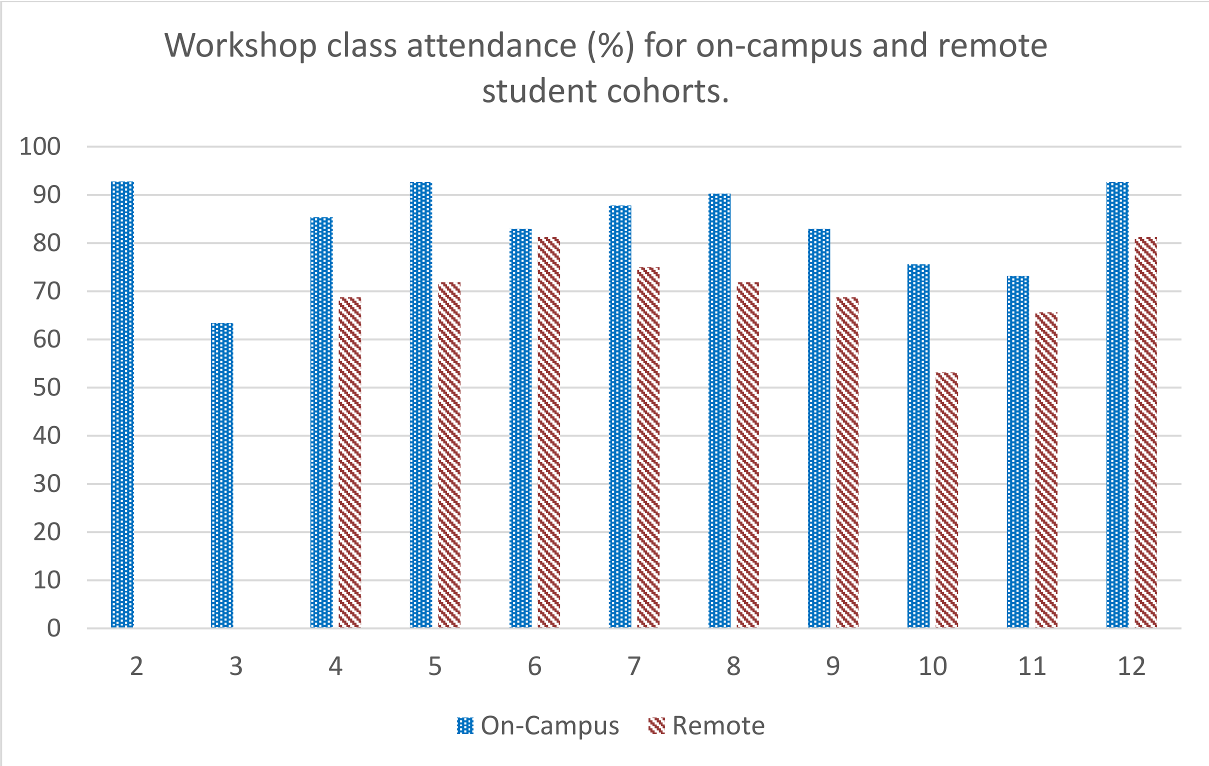


**Figure 2 Workshop class attendance (%)**

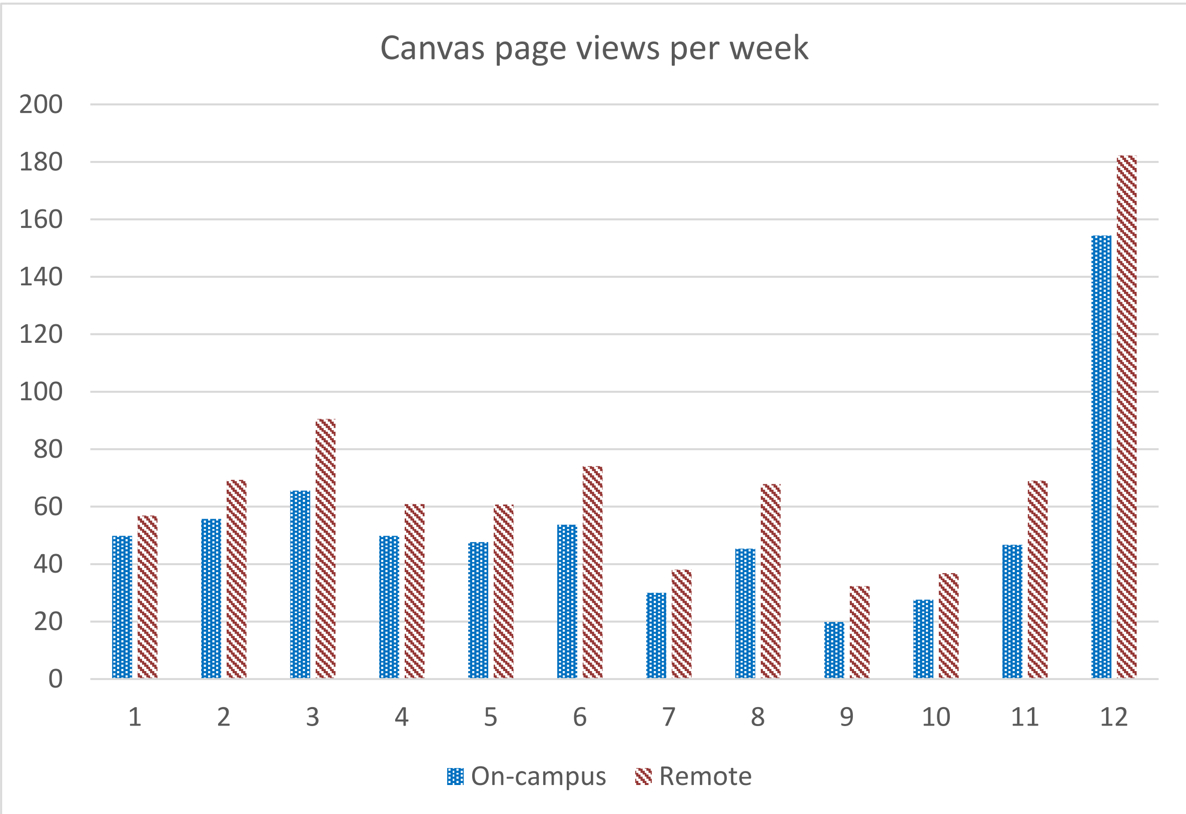


**Figure 3 Average weekly Canvas page views per student**

### Canvas access rates

Figure 3 plots the average number of canvas page views per student for the on-campus and remote student cohorts for active teaching weeks. Note that remote students consistently used Canvas more than on-campus students, an average of 29.8% more over the 12 weeks.

### Tutor feedback

Informal tutor feedback throughout and after semester indicated that students were less engaged in the online learning activities, with some online students not attending their "virtual" workshop sessions. Online only tutorials (different to workshop sessions) that expanded and applied material delivered in lectures had low attendance for both the online and physical cohorts.

### End of semester student survey

End of semester student comments from the routine institutional student surveys (USS) were reviewed for relevant comments, with those of most relevance to this study presented below:

Question: What have been the best aspects of this unit of study?

- *Workshop aspect is enjoyable.*
- *The teacher of the workshop taught very well and professionally. He helped me a lot.*
- *The physical workshop was extremely useful and fun.*
- *Give us great many chances of creations*
- *The laboratory, practical stuff was really good, learnt a lot about machining and actual information that will help me in the future*
- *Best unit ive had this year. Made friends learn how to communicate in engineering terms*
- *Making something physically*
- *The fact that we actually make something.*
- *The best aspect of this unit is that we can design our own engine.*
- *in person workshop!*
- *Physical labs. Excellent opportunity to learn.*
- *I have learned a lot throughout the course and had a great time! Our tutor is extensively supportive and is trying to help every single time I have asked a question. We also went over the workshop time since we have too many questions to ask. Our tutor has also helped us outside of the virtual workshop by responding to a number of emails we sent.*

What aspects of this unit of study most need improvement?

- *After returning to school, I hope the teacher can arrange us for more practical operations.*
- *If the tutorials were in person then they would be more helpful and engaging.*
- *More manufacturing guides for virtual pathway if there will be any in the next semester*
- *Online aspects of presentation such as the tuts*

### General observations and discussion

On-campus students received an average final mark for the unit 9.9% higher than students studying remotely, and this was reflected across almost all assessment tasks (exception of the project outcomes task which was assessed differently).

On-campus students had an average workshop attendance rate 14% higher than remote students, this is likely because they needed to physically machine their device components and remote students may have only sent some of their team to the online workshop session to seek help from the tutors, though they were all expected to attend.

Remote students however had a 29.8% higher Canvas access rate which is a large difference and may indicate they were seeking more information than their on-campus peers or reviewing lecture and other material more often.

Of particular interest is the mark difference for the individual tasks not directly associated with the major group project, with the on-campus students receiving an average mark 10.9%

higher in individual tasks than the remote cohort. This is interesting as only the workshop components (group project) had on-campus activities (workshop sessions) so it could be expected that there be no difference in remote and on-campus results for the individual tasks. It is possible that remote students were generally less interested and engaged in the unit due to their experience being entirely online, however, assignment 1 was due at the end of the first three weeks, and it could be reasonably expected (and hoped) that students would not have lost interest in the first few weeks! It is also possible that differences are due to approximately 2/3 of the remote students being offshore with English as a second language; these observations are worthy of further investigation.

For the major project tasks, it can be observed that both cohorts improved their marks for the three group report tasks by 30% (on-campus) and 25.7% (remote) which may indicate that students were learning from the unit and using feedback to improve their teamwork, report writing and engineering drawings skills, a positive outcome.

Another potential reason for the lower mark outcome for remote students is the different environment for teamwork collaboration, online and face to face, though in the authors' experience it is certainly possible for students to participate effectively in teams in an entirely online environment using Zoom, Google shared documents and other collaborative tools.

# Conclusion and future work

It is very difficult to replicate all experiential learning outcomes in an online environment, and particularly so when the activities involve hands-on aspects such as using workshop machining equipment. Videos of machining processes can be used but cannot replace a true hands-on experience. Student comments from the end of semester survey indicate they enjoyed the hands-on workshop experience and were potentially more engaged in that activity.

The use of Solidworks by students to create a virtual 3D working kinematic model of their design was beneficial as it improved the students' knowledge and skills with solid modeller packages, helped them visualise their device in 3D simulated motion, thus helping their understanding of basic machine design and functionality.

One alternative to the complete separation of on-campus and remote students would be to create teams of students that combine on-campus and remote students, with remote students observing some of the live on-campus workshop sessions via Zoom or similar technologies. This was not used in 2020 as previous experience has found groups generally need 3-4 members to physically complete their devices in time, and larger groups would potentially mean students may not contribute at the expected level in group report writing, drawings etc.

(Wood et al., 2005) found that many students studying engineering are coming from a background where they have spent more time playing computer games than 'tinkering' with machines and tools, it seems likely that developing virtual resources using gamification could benefit modern students. The 'lathe safety simulator' is one such example http://www.lathesafetysimulator.com/

There are several proposals that could potentially improve the learning experience for remote students in future offerings of this unit (and similar ones):

1. More extensive use of machining videos and in particular ones filmed in the actual student workshop, with their fellow student peers.
2. Potential use of 360degree VR videos to create a better feeling of immersion in the workshop environment.
3. Hybrid groups with on-campus and remote students with live Zoom cross-over sessions for remote students to observe workshop activities.

Unfortunately, due to COVID-19 related stay at home orders for Sydney from late June onwards in 2021 it was not possible to run physical workshop sessions and the entire student cohort completed their project in an online “virtual” form in 2021. More extensive use of videos and potentially also live Zoom sessions showing workshop technicians machining student designs is being considered for 2021 to help achieve the learning outcomes related to machining. The authors intend to continue this study.

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