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# Why do Engineering Students Attend Labs?

**Stephen B M Beck[1], Panos Lazari, Matteo DiBenedetti**

**University of Sheffield, Sheffield, UK**

## ABSTRACT

There is often poor attendance at timetabled laboratory sessions. Previous research into why university students attend lectures reports major disincentives are: being ill, the lectures not being interesting and not examinable. However, there has been no work on student drivers to attend laboratories, so the main aim of this work was to find out why students do or do not attend labs. It was also of interest to find out why staff thought students' drivers for attendance were.
The authors sent a questionnaire to students and staff in their Faculty of Engineering to find out what the drivers were for attendance and non-attendance. Questions were also asked about lab duration and group size. 184 students and 43 staff questionnaires were returned.
It was found that the main reasons that students do not attend labs were similar to those stated in the literature for lectures.
Staff can encourage students to attend labs using the reasons that students believe them to be important. This work will aid teachers to incentivise students to attend their practical sessions. of our approach, we quantified the percentage of student participation, which increased by more than 20%, as well as a set of generated lessons learned that attest to deepening the acquired knowledge.

## KEYWORDS

Laboratory teaching,
Student Attendance,
Group size

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## Introduction

Engineering is a practical subject and in common with the sciences, laboratory experimentation is a vital part of students' engagement with and learning of the subject. For example, in the UK, The Engineering Council require a practical element for a course to be accredited. However, the laboratory experiment element of courses tends to be a bit of a 'Cinderella' element of the course; something that exists but is not at the forefront of lecturers' and students' minds when they think about their experiences and education.

At the University of Sheffield, the faculty of engineering has consolidated the lab provision for its 6400 undergraduate and taught postgraduate students into a centralised provision. There are a number of large laboratories shared between the 7 departments and 3 non-departmental courses. For a number of reasons, a department (Multidisciplinary Engineering Education) was set up with a staff complement of about 50, to deliver almost all the laboratories and practical education for the students

[1] Corresponding Author : Stephen Beck – s.beck@sheffield.ac.uk

in the Faculty of Engineering. The efficiency and quality gains of this system are palpable and measurable. For example, lab utilisation is very high, in many cases above 90%, and student satisfaction is high. However, there still remains the interesting issue of the student experience and more importantly the effectiveness of the learning experience for the students. The staff in the department delivering the labs naturally think labs are both important and enjoyable, but is this what students think? Is it what staff who deliver the courses that labs support believe?

One issue that is becoming more visible is that student attendance at laboratories can be patchy. It can vary from a complete lab full of students to almost none of the 80 expected. So, it has become a priority to find out what drivers encourage and discourage students from attending laboratories. As part of this, it is useful to examine students' expectations of labs. To triangulate these expectations, it is also valuable to find out what staff think about the purpose of laboratories and what they think encourages students to attend. The latter may be key, as research by Moore (2003) has shown that staff encouragement can promote student lecture attendance.

## Literature Review

There is surprisingly little literature on the laboratory experience in general. There are numerous papers on laboratory experiments and the student impression of these, but not the drivers for attendance. There is also a large number of papers describing individual laboratories and their teaching and assessment. An early plea for laboratories as part of engineering courses, acknowledging the cost of putting them on was made by Hammond (1971) showing that this debate and the issues around lab provision predate the enormous expansion of the UK's universities from the 1980's. The contemporary, seminal work of Bligh (1972) states that 'Lectures can be coordinated with laboratory work' but expands no further.

Due to the lack of research on laboratory attendance, it was thought best to examine the use of the literature for lectures as the closest to that for lab attendance. There has been an enormous amount of discussion and research on student attendance and performance, at lectures. For a while there was only anecdotal evidence on this, however, an early report on this is that of Launius (1997) . They reported that students who attended classes did better on the exam. They also reported that students, when questioned, wanted marks for mere attendance. This latter finding is an ongoing theme in subsequent work on student attendance and performance. Indeed, Clump et al (2003) state that students attend more on 'quiz days' and those that attend tend to perform better overall.

Previously, Wyatt (1992) looked at the attendance rates of first-year Sociology students. They divided the responses into attendance for classes the students liked and those they disliked. The discussion states that students like high-quality lectures from prepared staff and if the topic is intrinsically less interesting, they like to see the relevance of it. This work clearly showed that alcohol consumption is an important factor in non-attendance (due to hangovers and oversleeping). Finally, they state that students with good grades attend more, but to keep up their grades. These latter two findings are a theme that reappears regularly throughout the literature.

In a key paper on this topic, Friedman, Rodriguez, and McComb (2001) again look at the reasons why students do not attend lectures. This was done by looking at first-year Engineering students' views regarding performance and attendance. On analysis and correlation, they discount a lot of obvious reasons and received wisdom about many reasons. The myths about student attendance that they raise include those of gender, class standing (which other, later studies disagree with), age and employment. It does however again conclude that high-performing students are more likely to attend. They raise the issue that peer influence is a key driver; if a student can attend with friends, this is an incentive. In a more obvious outcome, they report that good teachers are more effective at encouraging students to attend. They also report key reasons for non-attendance as being unable to attend, competition with

other activities (both school and non-school (US)), and 'irresponsible leisure pursuits' (which is another term for the aforementioned 'hungover'). Teacher-related issues for non-attendance include poor lecturing, lack of clear incentive for attendance such as marks, or direct connection to the assessment. This is also supported by Devadoss et al (1996) who conclude by demonstrating 8 elements that will encourage attendance. These overlap well with other researchers, but they pick up an excellent one (number 5) that can be applied to experimental work of 'additional insights, discussion, and real-world examples helps to enhance the understanding of the subject matter'. Druger (2001) also lists elements that encourage attendance. Beaulieu (1984) shows that marks for attendance improve attendance, but other, physical rewards (sweets, pens) are almost as effective. Lockwood, Guppy and Smith (2006) confirm this and also add that compulsory lectures affect final marks to an insignificant amount.

There is a large corpus of work on what makes a good teacher, but one of the more popular early texts is that of Davis (1993) , though this can come across as somewhat didactic to the modern academic. This is also supported by the work of López-Bonilla and López-Bonilla (2015) although they appear to have missed a lot of the preceding literature and overplay the originality of their work. However, they point out that the style of delivery is an important element in whether students decide whether to attend or not. This could be a good aspect to examine when encouraging students to attend labs, as we have little idea what 'style' students appreciate, only experience and received wisdom.

Massingham and Herrington (2006) state that the popular lecture can be down to the 'likability' of the lecturer. They also state that 'It may be that today's students have benefited from learning in a constructivist manner and are simply bored by the instructivist approach they face in many university lectures.' They quote Dolnicar (2004) as identifying the group of students who attend to pass the course as 'Pragmatics'. When they questioned their students, it was clear that they wanted an authentic, constructivist, and interesting experience. It should be noted that they only got the views of students who attended the last lecture of the course. Druger (2001) includes one, not picked up by other researchers, that is 'Demonstrate that you care about students'. This is likely to be key to good student engagement and motivation.

Moore and Jensen (2003) keep up this theme with the view that attendance is vital and it is the role of the lecturer to encourage this. They support this view with a rigorous study where the author divided the class into two and regularly stressed the importance of attendance to one-half. Even though both groups had the same initial expectations of attendance and performance, the group who had constant encouragement attended more and consequently did better. This was reinforced in Druger's (2003) paper, whose main takeaway is that if the importance of attendance is stressed, both attendance and grades are improved.

Student questionnaires are also used in Lockwood, Guppy and Smith's (2006) paper. Here the author looked at how important students thought attendance was and the rates at which they then attended class. They again concluded that staff encouragement was vital to maximise attendance rates. To quote 'Instructors, in turn, can nurture and encourage such positive attitudes by making their classes as useful and interesting as possible as a means for increasing student involvement and decreasing classroom incivilities'. This is also supported by the more recent paper of Montalvão and Dupac (2018) , who come to much the same conclusion.

Stripling, Roberts and Israel (2013) put the same type of outcome on a firmer footing by applying Maslow's hierarchy of needs and Atkinson's (1957) expectancy-value theory of achievement motivation to examine reasons why students won't attend lectures. Among other things: large classes (above 45 students) are a disincentiviser, and scheduling (Fridays, long classes (3+ hours), or the only class of a day) can be a factor. But the major dissuaders are: attendance not being taken, the course

being available in another form or the material not being relevant to the exam. Poor quality lecturing is also a factor. Finally, based on these, they describe 8 ways of maximising attendance.

In the paper of Barlow and Fleicher (2011) , the authors interviewed students to see why they do not attend. They found that for many students, the transition from school to university is incomplete and they believe that their falling behind is structural rather than personal. The authors uphold that a better transition regime would more effectively shift the responsibility for engagement to the student.

Ulmer (2020) analysed student professionalism (attendance, punctuality, and assignment deadline behaviour) and final grades. Using statistical techniques they show that good students treat professionalism as any other task to be completed and ace this element. Poorer students tended to underperform in professionalism compared to their grades.

All of the foregoing has to do with lecture attendance. The authors' searches have not found any such research into reasons for attendance at laboratories, but there is a noticeable, more recent body of work to do with the effect of lab attendance on overall student performance. Moore (2007) states that high attendance in labs correlated with high course grades and lecture attendance. Missing an early lab increased the chances of missing later ones. So looking out for lab absences can identify students at risk of not engaging in other parts of a course.

Moore, Jensen and Philip (2008) showed that students who turn up to labs do better and that informing them of this encouraged engagement with labs. However, it is not clear if labs are here used as a marker for lack of engagement in general. Adair and Swinton (2012) used learning and performance before the first labs, to isolate the effect of labs from that of motivated students. In common with other researchers, they report that lab attendance (on an Economics course) enhances exam performance.

As shown in this literature review, a lot of research has been conducted on the factors that encourage students to attend lectures. There is also a noticeable volume of research that supports the fact that students who attend labs do better in the course. This latter assumes that there is a proportion of students who do not turn up for their lab sessions, but there are no reports of identifiable reasons for this lack of engagement. Moreover, the authors have been unable to find any published work on what encourages or discourages students from engaging with the experimental part of their course. Furthermore, there are no reports on why staff think that labs are important and whether they encourage attendance in the same way as has been described and identified for lectures and lecturers. So what follows is a report that addresses and attempts to answer the research question:

'What are student and staff expectations of labs and what drivers affect student attendance?'

## Method

At the University of Sheffield, the labs have been moved into large centralised spaces with dedicated staff. This allows us to get large numbers of students through a single experiment in a very short time Beck (2023) . More information on this can be found in Appendix C.

Clearly if one wants to find out what staff and students' expectations of practical work are, they need to be asked. It was decided to use a questionnaire to find out what the staff and students in the Faculty of Engineering at Sheffield University think about what makes them attend or not attend laboratories.

First, the team obtained ethical approval for the work. This was somewhat simplified by the fact that we were not planning on obtaining any personal details from the students and the smallest staff groupings (of 5 and 15 staff) were agglomerated to ensure anonymity. Finally, we used Google Forms to set up the questionnaire. These are truly anonymous and as they were set up, it was impossible to ascribe any response to an individual. All responders were provided with an information sheet (which

was approved as part of the ethics acceptance process) and then consent was obtained from all responders to use their submissions. They were given the opportunity to answer the questionnaire without it being included in the research. Permission was also granted to run focus groups, though it was later decided that this would not add value to the results.

This data from both staff and students was taken over a 6 week period around February 2022. It should be noted that the previous year or so was very disrupted due to the COVID-19 pandemic, so some questions were also asked about respondents' previous lab experience, Though these were not included in the analysis as they added little and the student's experience was recently post-Covid.

As part of good research practice, a test questionnaire was sent out to a small sample of students (one small third-year class) and several staff members in the faculty. This was to find out if we were asking the correct questions to be able to obtain valid and useful results. If there were a number of similar suggestions, these would be incorporated into the real questionnaires which would go out to about 6000 students and over 500 staff.

It also allowed us to do some initial analysis to see what needed to be strengthened in the full-scale questionnaire. One of the things that came out of this was that students liked to work in smaller groups (pairs ideally) than the staff thought was best (typically groups of 3 to 5 students). So a question on the staff questionnaire was added to capture this too. There were few useful free text replies, so it was not deemed necessary to add any more options to the questionnaire. It will be noted that especially for students, we are asking about the totality of the laboratory experience so it would be legitimate for a student to select both 'too hard' and 'too easy' for their experience, if both these were in different experiments. The staff questionnaire was similar, but asked about the labs on their course, what they thought was important, and why they believed that students might or might not attend. A copy of the final student survey is shown in Appendix A.

## Results

In a key part of the questionnaire, students were asked about what disincentives they had for lab attendance. They could select as many options as they wanted. The results of this are shown in Figure 1. This is subdivided into responses from students who enjoyed and did not enjoy labs, as they answered another question. The reported percentages are normalised by the number of responses in the grouping - in this case, the 397 responses from students who enjoy labs (blue, top line of the pair) and the 98 from those who do not enjoy labs (red, bottom line). The three bottom options in this figure which refer to online labs and the specific additional learning from the experiments are ones where students who like labs give very low responses, whereas those who dislike labs ticked this option relatively often. Students who select this probably do not value the laboratory experience and wish to obtain their learning elsewhere (or possibly not at all). As students could select as many options as they wanted, it is notable that (on average) each student who did not enjoy labs (23 students) selected more responses (4.3) than each of those who did (141 students, 2.8 responses per student).

The most selected disincentive to attendance is that they have deprioritised the laboratory because they have another assessment that needs to be completed. This is true irrespective of whether the student generally likes labs. The next greatest disincentive is how they are feeling. This is slightly more of a disincentive for students who like labs. This may well be that this is one of the only events that would stop them from attending. Both of these major reasons for non-attendance are the same as reported for lectures by Friedman, Rodriguez, and McComb (2001). The third greatest disincentive was that the labs were too long. This is probably allied with the student being too busy doing other assignments.

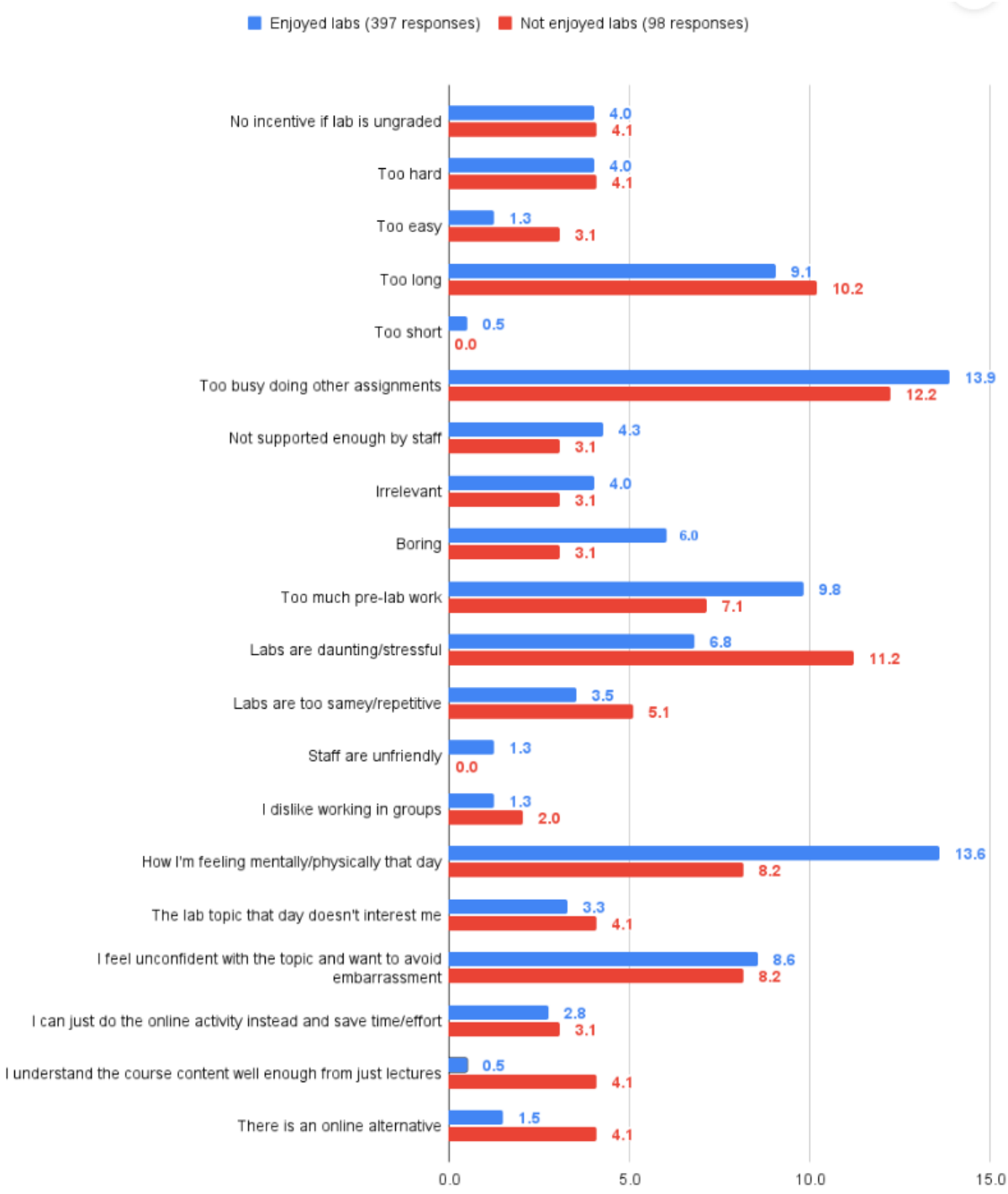


Figure 1 : What reasons discouraged students from attending labs? Results are normalised by response numbers in grouping

A key question that was asked of the students was what would make them more likely to attend their labs. This is shown in Figure 2, where data are plotted using the same normalisation as the previous figure.

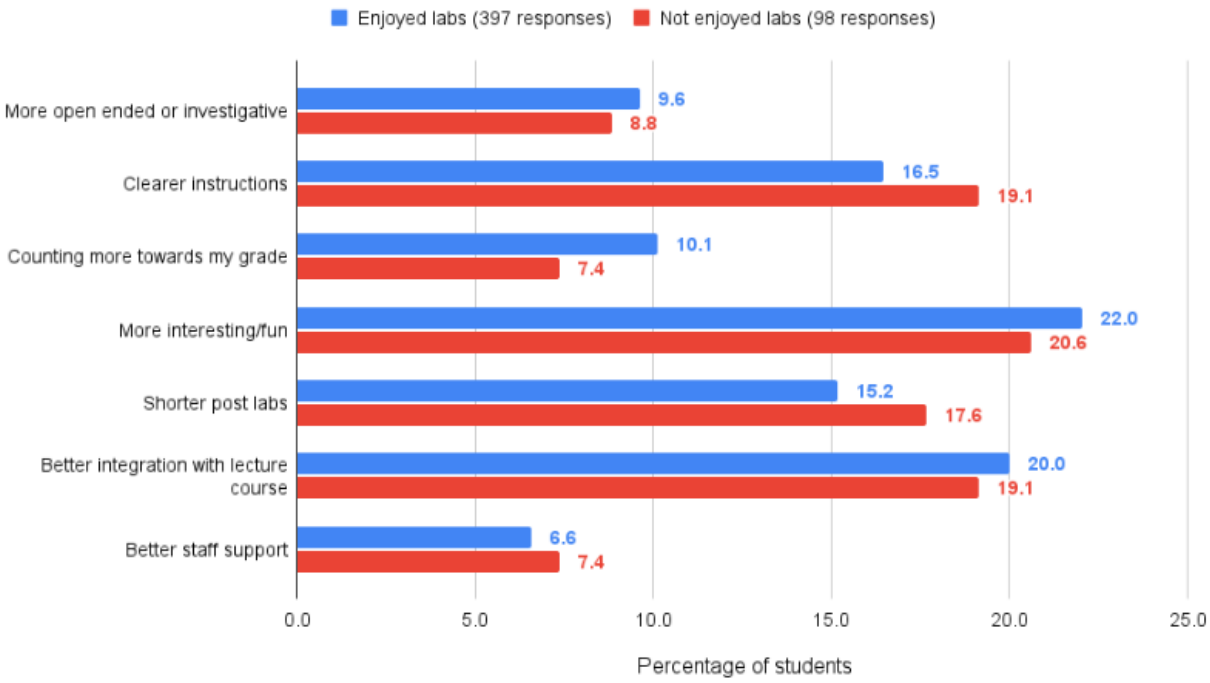


Figure 2 : What would make students more likely to attend? Results are normalised by numbers in grouping

What would make students more likely to attend? Results are normalised by numbers in grouping.

It will be seen that there is little difference in the responses between students who like and dislike labs. This might be somewhat surprising as these might be thought to come from different student populations. The one exception to this is that students who like labs would be more likely to attend if they counted more toward their grades. This could be so because they are already happy with the other aspects and that is the main perceived deficit.

The top incentive is for laboratory experiments to be interesting and fun. Once again, we see this as being the same that Friedman, Rodriguez, and McComb (2001) found for lecture attendance. It is clear that students only have a finite amount of time and if the laboratories are very tedious and boring, students would rather spend their intellectual endeavours on something they feel is more worthwhile.

The second avowed incentive is better integration of the labs with lecture courses. As stated in Appendix E, at Sheffield University in the Engineering Faculty, the large laboratories with multiples of equipment allow hundreds of students on a course to do a given laboratory in a window of a couple of days. However, for a number of experiments, this is not true and students will have experienced both approaches to the timing of laboratories. It is clear that the student preference is for laboratories to be timed closely to the topic being taught to better support their learning.

One of the key questions that students and staff were asked was what they thought labs were for. Additionally, staff were asked what they thought students believed was the purpose of labs. They were given a number of key options. The results from this are shown in Figure 3.

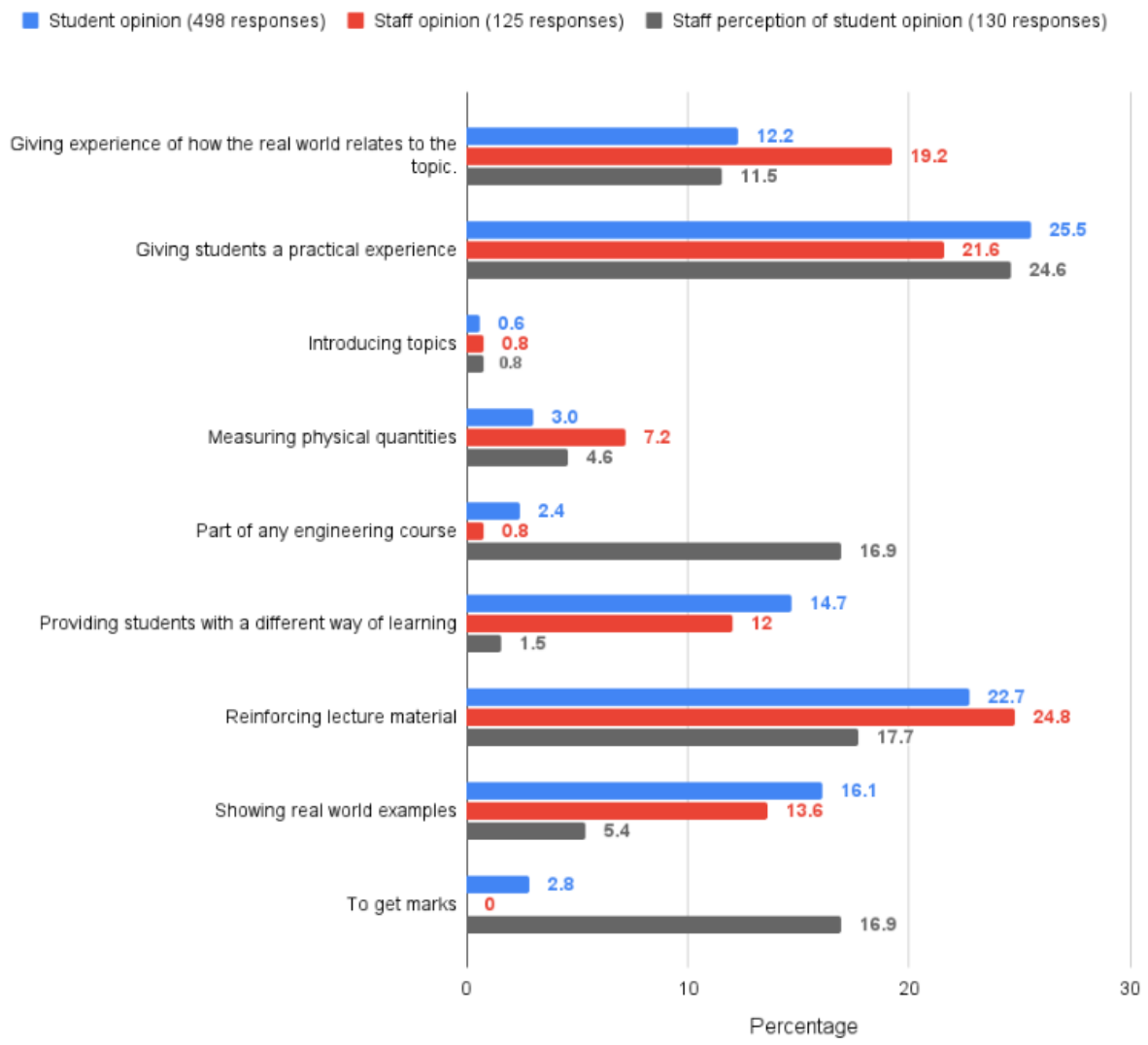


Figure 3 : What is the purpose of a lab? Results are normalised by numbers in grouping

What is the purpose of a lab? Results are normalised by numbers in grouping

It will generally be seen that all three answer sets agree that labs are important for reinforcing lecture material. This is not surprising as the literature such as Young, Nichols, and Cartwright (2020) states that different ways of approaching material can better support learning and learners. Staff and students also agree that labs provide support to the practical experience, but staff do not think that students believe they are there to provide a practical view of the labs. Staff and students also report that the labs are important to give experience of how the real world relates to the topic. The staff's view of students is similar here to students' views of themselves.

Two answers indicate a mismatch between staff and student expectations and staff expectations of students. Staff report very strongly that they believe students attend labs for the marks. However, students do not claim that the marks are a major driver for their attendance. The other answer where staff and students agree, but staff expectations of students' drivers are different is that staff think that students expect practicals as part of an engineering course. This may be an oversimplification or may reflect on the fact that they are unaware of the work done at Sheffield University in integrating practical experiences into taught modules. This could also be an artefact of their own education.

The main response where staff and students differ is that students like the way that labs provide a link to the real world. Students think that this is an important aspect of the practical experience, whereas staff believe it to be less so and believe that students do not think it is important at all. This may be because many staff come from a more theoretical background and in any case are under the impression that students do labs to get marks and reinforce lecture material.

**Statistical Analyses**

To test whether this surprising result is just conjecture or a true effect, a statistical analysis was performed to determine whether there is a significant association between two categorical variables. The chi-squared test selected for use here is a statistical test that compares the observed distribution of data with the expected distribution, assuming that there is no relationship between the variables in the population (Montgomery, Runger & Hubele (2010)). In other words, the chi-squared test helps to assess whether the differences between the observed and expected frequencies are likely due to random chance or if they indicate a real relationship between the variables. The test hypotheses are often stated as

H0: The distribution of the outcome is independent of the groups.

H1: The distribution of the outcome "depends" on the groups.

The latter could also be rephrased as "there is a difference in the distribution of responses to the outcome variable among the comparison groups". In order to test the hypothesis, the discrete outcome variable is measured in each participant in each comparison group. The formula for the test statistic for the chi-squared test (Montgomery Runger and Hubele (2010)) is given below.

Where O is the observed frequency and E is the expected frequency in each of the response categories in each group.

The independence of "what staff thinks labs are for" and "what students think labs are for" are investigated by studying their observed distributions. For this purpose, a chi-squared test (significance level, $\alpha = 5\%$, indicating the probability of a false rejection of the null hypothesis in the statistical test) was carried out under the null hypothesis that the distribution of the outcome is independent of the groups (i.e., staff and students say the same thing). There was not enough statistical evidence to reject the null hypothesis, $\chi 2$ (df = 8, N = 623) = 14.60, p = 0.067, thus implying that students' and staff's perception of what labs are for is matched.

What students think labs are for, and staff perception of what students think labs are for

The independence of "what students think labs are for" and "what staff's perception of what students think labs are for" was investigated by studying their observed distributions. For this purpose, a chi-squared test (significance level, $\alpha = 5\%$, indicating the probability of a false rejection of the null hypothesis in the statistical test) was carried out under the null hypothesis that the distribution of the outcome is independent of the groups (i.e., staff' perception of students and what students think match). The relation between these variables was significant, $\chi 2$ (df = 8, N = 623) = 101.4, $p < .00001$, thus the perception of what staff considered to be the reason for students to attend labs did not match what students thought the labs were for.

So this gives further credence to the view that students are more sophisticated in their understanding of why labs are included in programmes than staff think they are.

## Conclusions

No publications have been found that address the issue of student attendance at labs. However, it has been found that the reasons that students do or do not attend labs are very similar to those reported in

the literature for attendance at lectures. These are making them interesting, not too long and timed to coincide with the material being delivered in the associated course.

Marks are not a great incentive for attendance, contrary to received wisdom. However, the time devoted by students to laboratories must be seen as valuable to the students.

Students will prioritise other work, which leads directly to marks over attending laboratories. Once again, this is a similar result to that reported in the literature for lecture attendance. Finally, it must be noted that students are reporting from their own experiences. Students with different prior experience and university practical experience may have different views on drivers for laboratory attendance, duration and group size.

There is a mismatch between staff impressions of student drivers to attend and student drivers. However, there is a broad agreement between what staff and students believe labs are for. If staff are more aware of why students value labs, it will be easier for them to encourage them to turn up to the sessions. This could be done by better 'advertising' of the labs in the lectures. Now we know what many students value in labs, it is easier for lecturers to encourage students to attend. This type of information can also be useful to help staff decide what labs they want the students to do and what they want them to get out of them. Well-conceived experiments which help students become better engineers are going to appeal more than putting on a laboratory because the equipment exists or because you always have

One way to make labs more attractive to students is to actually look at what they are being tasked with doing and ensure that it is both valuable and interesting. The authors and the Department of Multidisciplinary Engineering Education in general are working on this. By implementing 'gamification' of the labs, reducing their duration and integrating them better in the courses, they are encouraging students to see that the labs are a useful adjunct to their learning and are worth prioritising over other activities. There are also a number of self booking labs where students can decide when they will do them. This approach can obviate the timing issues flagged by students.

**Future work**

Now that this data has been acquired, processed and contextualised, the next step in the research is to get staff who teach courses with a practical element to be better at encouraging students to attend by using an approach that will agree with their own views of the importance of labs.

It is also interesting to note that our impressions of the drivers to attend labs mirror those shown to affect lecture attendance. It would be interesting to see if there was a correlation between lab attendance and lecture attendance in the same course. Possibly some subjects or delivery modes are more engaging for students.

Other Universities which have a different approach to laboratories may well have obtained different results from the same questions to their students. To this end, working with other establishments on an investigation would allow us to investigate the generality of our findings and also see whether these results were affected by the students' own positionality and experiences.

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## Notes on Contributors

Stephen Beck is Professor of Mechanical Engineering at the University of Sheffield, Director of the Sheffield University Centre for Engineering Education

Panos Lazari is a University Teacher at the University of Sheffield.

Matteo DiBenedetti is a Senior University Teacher at the University of Sheffield.

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