Journal of Biological Education

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/rjbe20

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To cite this article: Andrew P. Dean, James Redfern & Kirsty J. Shaw (28 Jan 2025): Student attitudes to, and achievement, in an innovative and authentic biotechnology assessment based on a 'consultancy Response to Tender', Journal of Biological Education, DOI: 10.1080/00219266.2025.2450301

To link to this article: https://doi.org/10.1080/00219266.2025.2450301

JOURNAL OF BIOLOGICAL EDUCATION
https://doi.org/10.1080/00219266.2025.2450301

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Student attitudes to, and achievement, in an innovative and authentic biotechnology assessment based on a 'consultancy Response to Tender'

Andrew P. Dean, James Redfern and Kirsty J. Shaw

Department of Natural Sciences, Manchester Metropolitan University, Manchester, UK

ABSTRACT

In recent years, there has been a significant reappraisal of assessment in HE, with increased attention towards authentic assessments, which are defined as those that are 'authentic or work relevant', or that 'change the nature of student engagement or participation'. This paper investigates the design, implementation, and evaluation of an undergraduate unit based around an authentic assessment – the delivery of which was atypical to previous student experience. The unit had a modular structure with three separate mini-projects, each student writing up one for the consultancy style 'Response to Tender' assessment. Quantitative data were analysed for in-person attendance, online engagement, and assessment mark, while student attitudes towards the assessment were collected via questionnaires. Students reported high satisfaction, appreciated the real-world applicability, and identified the unit as providing useful skills for the future, including employability. They appreciated the active learning approach employed, stating that the design and approach of the unit encouraged attendance. The evidence provided here shows that the adoption of authentic assessment approaches, with assessments clearly linked to real-world applicability, can lead to high student satisfaction and engagement, and a positive student and staff experience.

ARTICLE HISTORY
Received 26 June 2024
Accepted 15 November 2024

KEYWORDS
Authentic assessment; innovative assessment; alternative assessment; active learning; biotechnology

Introduction

Assessment is integral to quality teaching and learning, which is fundamental to higher education (HE). In recent years, and particularly over the last two decades, there has been a substantial rethinking of assessment in HE, with calls for a significant, evidenced-informed repositioning of assessment processes and practices (Elkington 2020; Harrison et al. 2022). Traditional assessments, such as essays or traditional exams, may be considered by students as arbitrary and irrelevant, and simply test their ability to memorise material, or marshal facts and details leading to ineffective learning, while the activities associated with traditional assessments can consist of 'routine, dull artificial behaviour' (Struyven, Dochy, and Janssens 2005). There is evidence that students feel alternative assessment approaches to be fairer, and more useful, as they measure qualities, skills and competencies which 'would be valuable in contexts other than the immediate context of assessment' (Struyven, Dochy, and Janssens 2005). These alternative assessments are often innovative, for example, podcasts, or elevator pitches, or maybe authentic, in that the assessment task requires

CONTACT Andrew P. Dean andrew.dean@mmu.ac.uk
Supplemental data for this article can be accessed online at https://doi.org/10.1080/00219266.2025.2450301

students to demonstrate their knowledge and skills in meaningful contexts and apply their learning to real-world contexts (Swaffield 2011).

Alternative and innovative assessments can foster a deep rather than surface learning approach (Nicol 2009) with deep learning implying the demonstration of higher-order thinking skills such as synthesis and evaluation, and a personal commitment to learn the material, rather than simply aiming to pass or achieve a high grade (Biggs 1987; Entwistle, Hanley, and Hounsell 1979; Jackson 2012; Ramsden 2003). Alternative assessment approaches can also encourage productive learning and engagement from students, and if designed well, can promote lasting, worthwhile learning (Sambell, McDowell, and Montgomery 2012).

Of alternative assessment approaches, students highly value assessments that have real-life applicability or simulate real-world scenarios or tasks that students could face on gaining employment, with these assessments enabling students to show the extent of their learning, while allowing them to articulate more effectively precisely what they had internalised throughout the learning program (Sambell, McDowell, and Brown 1997). Analysis of student perceptions of alternative assessment types found a positive effect on learning when the assessment task related to authenticity, had reasonable demands, was realistic, developed skills, and was perceived by the students to have long-term benefits; therefore, we should be rethinking and redesigning assessments to encourage productive learning and engagement from students (Sambell, McDowell, and Montgomery 2012).

A specific type of alternative and innovative form of assessment, which meets the characteristics outlined above (real-world relevance, applicability beyond the assessment task encouraging deep learning) is the previously mentioned authentic assessment. Authentic assessment is any assessment that reflects or simulates a real-life situation and requires students to use the same knowledge, skills, attitudes and competencies that the students would face when they enter professional life and employment (Gulikers, Bastiaens, and Kirschner 2004).

However, authentic assessments are different from the traditional assessment approaches within HE, which are often dominated by traditional assessment types, such as exams and/or essays. McDowell and Sambell (1999) state that 'Students do not necessarily welcome innovative approaches to assessment. Although often critical of conventional methods, there is safety and security in the routine and the familiar which any changes may threaten'. Other studies have found that students have marked preferences for different assessment types and may prefer traditional assessment approaches (Struyven, Dochy, and Janssens 2005).

As authentic assessments can change the nature of student engagement or participation, they can also require a change in student approaches. Depending on the form of the assessment, the students may need a greater commitment – e.g. regular attendance at sessions to benefit from the instruction and feedback in developing new skills, and a greater commitment to understanding the requirements of the assessment task. For a student to do well with an authentic assessment task, they will need a deeper approach to learning, with students needing to be less *passive* in their learning and be more *active* learners, with less focus on, for example, memorising course material to be reproduced in an exam. However, as Bloxham and Boyd (2007) state 'Changing the assessment may change the approach of some students who perceive the new requirements appropriately but will not necessarily change every student's approach to learning'. So, whereas some students may adapt to the innovative assessment approach, and a deeper more active learning style, other students may adapt less well. Therefore, when introducing authentic assessments, we need to ensure that students understand what is asked of them, and have the appropriate skill set to approach the assessment task i.e. assessment literacy (Price et al. 2012) and understand their attitudes towards new assessment types, and any changes in teaching approach (e.g. active learning) that are associated with the authentic assessment approach.

Sambell and McDowell (1998) looked at student perceptions of innovative assessments and showed that although students understood and adapted to these assessment types, the perceptions they had of them were complex and varied from individual to individual, with students having

a range of experiences, motivations and perspectives, and that these perceptions in turn influenced their approaches to learning and studying. Therefore, it is important, when bringing in new assessment approaches, that we understand student attitudes towards the new assessment, how they approach it, and the extent to which they achieve the desired outcomes of the assessment task (Bartram and Bailey 2010; Bevitt 2015).

Although there are a number of papers looking at concepts around authentic assessment, and its definition (e.g. Ajjawi et al. 2023; McArthur 2023), there are few papers detailing how authentic assessment has been implemented at unit or course level, and in which student experiences have been sought, and few examples from the scientific disciplines. For example, a systematic review of authentic assessment literature by Sokhanvar, Salehi, and Sokhanvar (2021) identified 26 publications between 2010 and 2019 in which authentic assessment had been implemented in a higher education context, and where student experiences were examined via surveys or interviews, of which only one paper relates to biology.

This paper describes the design of a unit in the field of biotechnology, entitled 'Frontiers in Biotechnology', which was designed around an authentic assessment (consultancy tender response), with the unit content reflecting real-world problems with biotechnological solutions. The unit was taught with a focus on active learning, which was less familiar to the students compared to the more traditional form of lecture-based units with exams. Authentic assessment (and the active learning approach employed to provide the students with the knowledge and skills to approach the assessment) was also less familiar to the unit staff, who had tended to teach in more conventional lecture-based units with end-of-unit exams. It is therefore important to evaluate student attitudes towards the unit and its assessment, student engagement with the unit materials and approach, as well as student achievement. It is also important to determine the extent to which the students achieved the desired unit outcomes which were: to provide knowledge and understanding of Biotechnology through active learning via laboratory practicals, while utilising an authentic assessment (consultancy tender response) with real-world applicability; to gain an appreciation of real-world scenarios, and an awareness of the applicability of the knowledge and skills gained for the solving of real-world problems; and to develop a strong skillset, and to heighten awareness of skills related to consultancy report writing, problem-solving, applied research, practical laboratory skills, data analysis, critical thinking, project management, literature searching, and research design.

The overall aim of this paper is therefore to evaluate the extent to which these desired outcomes for the unit were achieved, with the overall evaluation considered in terms of 'Student Attitudes', 'Student Participation' and 'Student Achievement'. In particular, this paper seeks to achieve the following objectives: to capture student attitudes towards the approach used in this unit – for example, how they viewed the authentic assessment, the knowledge gained, the skills gained, and the real-world applicability of the material; to understand the extent to which the innovative and authentic assessment approach helped their learning and encouraged their engagement with online materials and face to face learning; and to understand student achievement in terms of the extent to which they achieved good marks and completed the assessment requirements to a high standard.

Assessment approach and unit design

The unit consists of three mini-projects, each based around a real-world problem (namely toxin-producing algal blooms, acid mine drainage and foodborne pathogens) that can be solved through a biotechnology approach. Each mini-project was designed and delivered using a common framework, with a focus on laboratory-based learning with supporting lectures for underlying theory. The assessment was presented as three separate 'Invitations to Tender' (one for each mini project) in which a client outlines a problem and the requirements of the client. Students select one mini-project for their assessment (SI Tables S1–S3 show the structure of the unit in terms of how material

was presented, and assessment details) with the student acting as a consultant, who presents their solution via a 'consultancy tender response', written in a format and style of a consultancy report.

The students therefore receive an 'Invitation to Tender' describing a problem, and in their 'Response to Tender' assessment describe how they would complete the work and justify their choice of solution (the solution is that which the students themselves developed during the unit delivery). The 'Response to Tender' consists of six questions that the student must answer (SI Table S4). The questions require the student to outline the proposed solution, explain the basis for how it works, justify it as a viable and effective solution, and provide an outline of costs and timescales. A detailed marking scheme was prepared and was available to students throughout the unit – the development and availability of which plays a key role in students' ability to complete assessments and understand the requirements of the assessment task (Murphy et al. 2017). The questions are the same for all mini-projects/tenders. In addition to the six specific questions, the students must also answer any client-specific requirements, which they must incorporate into their answers.

An advantage to the design of the unit employed here – with three separate subject areas and a choice of which to be assessed upon - is that it offers students within-unit optionality, improving the chance of students finding material that is interesting to them and/or aligns with their goals and ambitions (see SI Table S1). University students often express a preference towards the provision of a number of optional units and the choice that is provided, while on the other hand university administrators and leaders sometimes wish to rationalise courses and units, so that there is less optionality, with less units, with more students on each, thus maximising efficiencies in staff teaching commitments. The design of the unit provides within-unit flexibility, in that the modular structure, with three taught mini-projects/areas, means that other subject areas/mini-projects can be easily slotted in, if for example there are changes to unit staffing, meaning lecturers' new to the unit will not have to learn new unfamiliar material but can present and adapt their own subject/research area in a new context.

Methodology

Research design

The research worldview of this study is pragmatism. Pragmatism involves solving problems in a practical and pluralistic way that combines methods, rather than having adherence to a particular worldview or paradigm (Kivunja and Kuyini 2017). When considering ontological and epistemological positions, a pragmatic study using a mixed methods approach will combine data and approaches that are both quantitative (post-positivism) and qualitative (constructivism) (Creswell and Plano Clark 2017). The research question and aim of this study are to evaluate student attitudes towards, engagement with, and achievement in a unit employing an authentic assessment approach. The research questions require an understanding of qualitative data (student attitudes to the unit teaching approach and authentic assessment) and quantitative data (student attendance, online interactions and assessment marks). A mixed methods approach is defined by Creswell (2015) as 'An approach to research. . .in which the investigator gathers both quantitative and qualitative data, integrates the two, and then draws interpretations based on the combined strengths of both sets of data to understand research problems'. Therefore, the mixed method pragmatic approach is the most appropriate to the questions and aims of this study and forms the basis of the research design employed.

Sample

The participants in this study were 3rd year undergraduate degree (Biology, and Microbiology and Molecular Biology degrees) students at Manchester Metropolitan University, UK, who took the unit in the 21/22 academic year. The unit ran uninterrupted from COVID (October 2021 to

January 2022), and the cohort consisted of 43 students who attended the course and submitted the final assessment. For all students, quantitative data on attendance, online engagement with the VLE system 'Moodle', and achievement (unit mark) were available. For the questionnaire, a total of 26 responses were received, giving a response rate of 60%.

Data types and sources

Table 1 shows the data types and sources that were used in this study, with the study utilising quantitative data collected relating to attendance, online engagement, acheivement (unit mark), and student attitudes (via data collected on a Likert scale (questionnaire)). Further qualitative data on student perceptions was collected via free-text comments (also via questionnaire).

Questionnaire design

The questionnaire sought to gather student thoughts and attitudes towards the unit, and its assessment (see SI_Methods_Questionnaire). The questionnaire consisted of three sections: (1) General Unit Evaluation, (2) Questions about the Unit Assessment and (3) Questions on the choice of mini-project. There were 17 questions, including both free text and Likert scale. The questionnaire was completed in week 5 (of the 6-week course) during a practical session. To minimise the possibility of response bias, where students may have felt pressured to provide positive feedback due to the presence of instructors or peers, all questionnaires were completed and handed in anonymously, and the students were allowed to complete their responses at any time during the practical session.

Ethics considerations

All data collection, analysis and storage has adhered to General Data Protection Regulation (GDPR) guidelines. The data on participation (attendance), grades and engagement (VLE system 'Moodle') were collected by the University for all students as standard procedure. Data from the anonymous questionnaires were collected during the unit as part of the standard unit feedback process. Ethical approval was granted by the Faculty of Science and Engineering Ethics and Research Governance Committee (EthOS reference 40899). To ensure confidentially of the data collected from Moodle, all data was recorded under student numbers rather than names.

Statistical/Data analysis

All data from the questionnaire was entered into Excel. Each participant has a row, and each question has a column with corresponding Likert scale or free text data. Likert data were analysed

Table 1. Data types and sources used in this study. Data was both quantitative and qualitative and used data routinely collected by the university, as well as data gathered specifically for this project via a questionnaire.

	Quantitative Data	Qualitative Data	Data Source
Student Achievement	Student Assessment Mark		Data from MMU VLE system 'Moodle' and mark records as unit leader.
Student Engagement	Student Attendance		MMU 'Presto' engagement monitoring system
	Student Engagement with online support material		Moodle activity 'Logs' records
Student Perceptions	Student Perceptions via unit evaluations (Likert Scale)	Student Perceptions and Attitudes via open text questions	Questionnaire

and plotted using Excel. Free text comments were displayed as word clouds using Word Art (WordArt.com). Free text comments were also categorised on the basis of subject matter/theme.

Results and evaluation

Student attitudes towards the unit and its assessment

Student perceptions of the unit were determined via a Likert scale question on overall satisfaction. Despite the innovative nature of the assignment, and the different approach to the subject (lab-focused teaching, modular design with mini projects, only writing up ~ 1/3 of content delivered for the assignment), the data indicated high levels of student satisfaction with the unit overall with 96% of respondents either satisfied or highly satisfied (Figure 1(a)). Further information regarding student perceptions was provided via free text questions including the question 'What have you enjoyed most about the unit?' the feedback from which is displayed as a word cloud in Figure 1(b).

It was a desired outcome of the unit that the students would appreciate the 'learning through doing' approach in which the students were encouraged to find their own answers during active lab/practical sessions, rather than just being told the answers in a more didactic traditional lecture approach. Within the free-text comments it was Labs and Practical classes (students used both terms to refer to the same laboratory sessions, going forward these will be grouped as laboratory sessions) that feature most highly. Analysis of the free text answer shows that 20 out of 26 students (77%) mentioned Lab/Laboratory (15 mentions) and/or practicals (11 mentions) as being the most enjoyable aspect of the unit. Different (5 mentions) and Learn (4 mentions) were mentioned in relation to the different techniques or examples of biotechnology, reflecting the 3 mini-projects. Work was also referred to five times, but not in relation to work-based employment, but rather as

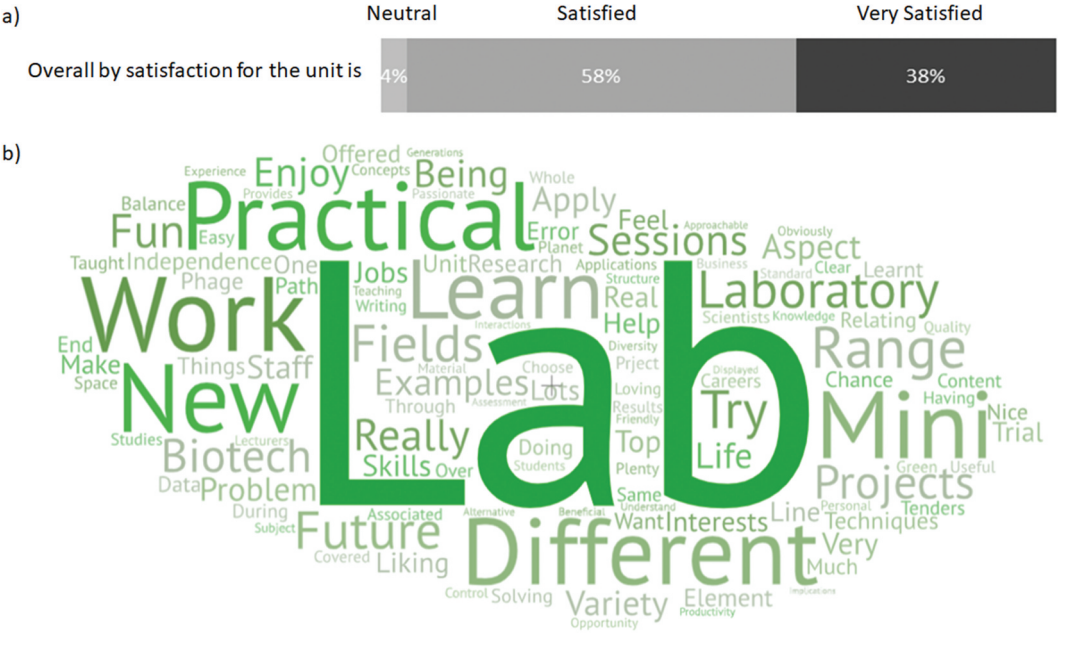


Figure 1. (a) Overall student satisfaction with the unit (b) word cloud illustrating the frequency of words used by students when answering the question 'what have you enjoyed most about the unit?'. Text size is proportional to a number of responses with the smallest font size e.g. that for 'experience' (top left) relateing to 1 use of that word across the 26 comments. The largest font size 'lab' represents 12 uses of the word across the 26 comments. Overall appreciation of the unit was positive. Highlighted words reflect the active learning (lab, practical) and also the innovative nature of the teaching approach, as well as the authentic assessment (work, new, different).

enjoying lab work or practical work. This unit was designed so that the students would engage with the assessment task, and design their own solutions to the problems outlined in the 'Invitation to Tenders' via lab-based practical sessions in which active learning was adopted.

Handelsman, Miller, and Pfund (2007) define Active Learning as when (as paraphrased by Brame 2016) 'students are engaged in their own learning. Active teaching strategies have students do something other than taking notes or following directions . . . they participate in activities . . . to construct new knowledge and build new scientific skills'. Laboratory practicals fall into this definition, but only if the learning experience is more than simply following directions, such as a written protocol – a way of learning described as 'recipe-based laboratory experiences [that] are generally boring, non-interactive and non-engaging' and 'unlikely to promote higher order thinking and learning' (Siddiqui et al. 2013). In this new unit under evaluation in this paper, active learning is promoted through laboratory-based learning, with practical sessions designed to encourage student autonomy and freedom in choice of methods and technical approaches, and the student feedback indicated that this practical-based active learning approach was appreciated by the students.

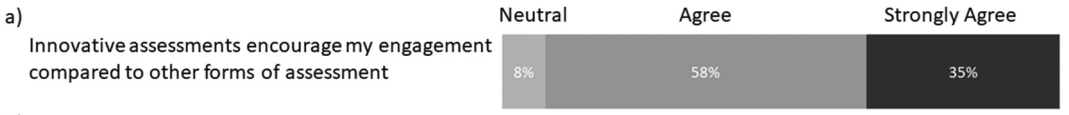
One of the concerns about implementing an authentic assessment in a new unit was that students only had limited experience with it, having completed authentic or innovative assessments in only a few other units. However, students did state that they gained confidence from having worked on those other alternative assessments (SI Figure S1a). This suggests that implementing authentic or innovative assessment approaches across a curriculum more widely will increase student familiarity and confidence with these assessment types. Students also understood the requirements of the assessment either fully (18 students) or partially (8 students) with no students feeling that they did not have any understanding of the assessment task (SI Figure S1b). Thus, the students did understand what was asked of them and can be said to have had assessment literacy (Price et al. 2012) regarding this assessment. Thus, although authentic and alternative assessment types can be unfamiliar to students, prior experience with these approaches, and clear instructions and guidance can alleviate problems with unfamiliarity.

When assessing student views of assessment types, authentic assessments, such as those employed in this unit, were grouped with other innovative assessment types, which they may have experienced in other units. Students did not rank innovative assessments as their favourite type of assessment (SI Figure S1c) – when asked to rank assessment types in order of preference innovative assessments were ranked as number 1 by only 6 students, though 13 ranked innovative assessments as their second preference, 6 as 3rd choice and 1 student ranked innovative assessments as their least favourite. The ranking of multichoice exams as their favourite assessment type is in line with other studies that show a preference for the multiple-choice format (e.g. Zeidner 1987). The reasons cited by the students in this study were that the multiple-choice format is less stressful and easier to complete than other assessments (free text answer to questionnaire question 8 - Why do you prefer the assignment you ranked first?). The popularity of coursework such as the authentic and innovative approach used here, over traditional exams, is in line with other studies showing coursework to be more popular than standard exams (Bartram and Bailey 2010), and the students ranked standard written exams as least favourite, with students considering them more stressful, and a test of memory rather than knowledge. The fact that innovative assessment, despite perhaps being difficult to complete, was ranked highly, as both first and second choice, suggests that alternative assessment approaches, such as that employed here are, when students experience them, highly ranked amongst coursework types.

Engagement

It was a desired outcome of the unit that the authentic assessment would encourage engagement (when compared to other forms of assessment). The answer to this was positive (Figure 2(a)), with 92% of the 26 respondents feeling that innovative assessments encouraged their attendance when

a)



b)

Interest	Knowledge	Pragmatic/Other
I've attended all other session because I find them all really **interesting**	Can always learn something. Better than missing out on potential skills **knowledge**	Just in case they are easier or get easy
Interested in other projects and wasn't sure which one to do until later in the block	To gain extra **knowledge** on other topics and more lab experience	Was told information would be passed on in other sessions
I was not 100% sure which I wanted to do and I found all 3 **interesting**	It will give me **knowledge** that will benefit me in the long run.	Gives you tips that I could apply to my mini project and it means I can change my mind at any point if I struggle.
They are **interesting** and they were on my timetable	Just in case I changed my mind. Always good to have a good **knowledge** of other topics	There is relevant info/applicable into all projects in all sessions.
I found all content in the sessions **engaging and interesting**. Teaching me other lab skills which could be useful in future. I was undecided with project choice for the majority of weeks and wanted to make an informed decision between the projects	To learn more **knowledge** because I find it all **interesting**, and how other tenders can be approached, and how working on different tenders can be assigned future prospects and careers	Fun
I am **interested** in the topics	Useful information on how to answer the tender and **knowledge** of all the different options	To gain more skills and techniques

Figure 2. (a) Likert data from the student questionnaire showing that 92% of the 26 respondents felt that innovative assessments encourage their attendance when compared to other forms of assessment, with 8% (2 respondents) neutral; (b) free text comments relating to why students continued to attend taught sessions that did not relate to the topic of their chosen mini project, showing enhanced unit engagement with the taught material.

compared to other forms of assessment (although this of course only captures the thoughts of those students who did attend, and therefore filled out the feedback questionnaire). This was evidenced by students continuing to engage with material which, once they had chosen their project to write up, they knew they would not be assessed on. One of the fears when designing this unit was that students would choose a mini-project early in the unit that they were going to write up, and then only attend those labs, and lecture sessions, and thus take a highly strategic approach to their learning, with students aiming to achieve high grades though selective learning of a particular topic. Although a small number of students expressed through informal conversation that they only attended sessions for the mini-project which they planned to write up, an interesting finding was that even after choosing their mini-project many students (23 out of 26 respondents) attended sessions other than that which they wrote up. Students therefore attended sessions where they knew that the material they were taught would not contribute to their assessment. The reasons students stated for continuing to attend sessions for mini-project topics that they were not writing up are given in Figure 2(b).

Reasons for attendance were categorised into 'Interest', 'Knowledge' and 'Pragmatic/Other'. Students citing interest as a motivational factor in attendance is in line with other studies, for example, Gump (2004) reported that 84.7% of 1st year undergraduate respondents indicated interest was a motivating factor for attendance. In this study, the authentic nature of the mini projects and the active lab-based approach encouraged student attendance, even in this case when they know the material will not be assessed. With an increasing awareness of the benefits of student attendance and presence on campus, this suggests that by carefully designing our unit assessments, delivery, and content (for example through research-led interactive, active learning teaching approaches) we can provide units that encourage attendance, so students have the wider university experience, and the benefits that campus attendance provides (Sloan et al. 2020). Sloan et al. (2020) also found that 68% of student respondents agreed with the statement 'I enjoy learning or knowledge acquisition for its own sake' with just 8% disagreeing, and the result from this study also shows that the students on this

course enjoy knowledge acquisition and learning for its own sake (Figure 2(b)). Other reasons for continuing to engage with material on which the students would not be assessed related to gaining more knowledge or skills and to transferring information given in the context of other mini-projects to their chosen mini-project.

Real-world awareness

A further desired unit outcome was to utilise authentic assessment to provide the students with an appreciation of real-world scenarios. That students did gain an appreciation of real-world applicability was reflected in the free text comments, with 'real-world' or 'real-life' related comments coming up in the free-text answers to 3 questions (Table 2). Twelve of the 26 (46%) respondents used the word 'real' positively when referring to the unit (no respondents used it in a negative way). Most comments were associated with question 12 (relating to what skills the unit provides to future careers) with one respondent stating that the real-life problems were one of the things they were most enjoying about the unit (responding to question 2 - 'What are you enjoying most about the unit?).

Five respondents directly mentioned real-world scenarios in their answers to question 8, 'Why do you prefer the assignment you ranked first?' all of whom rated innovative assessment (of which the assessment in this unit is an example) as their favoured form of assessment. Only one other respondent rated innovative assessment as their favoured assessment type, and although they did not directly mention the phrase 'real-world', their reason for favouring the assessment nevertheless reflected its applicability to jobs and careers. This suggests that for those students who ranked innovative and authentic assessments as their favoured assessment type, the reason was their real-world applicability. As stated in the introduction, one of the defining features of innovative assessments is that they are 'authentic or work relevant' (Advance 2024) and 17 of the 26 respondents (65%) mentioned the terms real-world or jobs/career relevance in their free text comments, indicating that the majority of students could see the relevance of the assessment to their future careers.

Table 2. Free text comments related to real-world scenarios, as distributed across answers to questionnaire questions 2 - 'what are you enjoying most about the unit?', 8 – 'why do you prefer the assignment you ranked first?' and 11/12 - 'the assessment for this unit provides skills for your future career, if you answered agree or strongly agree what skills do you think it provides?'.

Relating the practicals to real-life problems. Problem-solving aspects (q2)	It is closer to real job tasks (it is more similar) (q8)	Trouble Shooting. Learn different writing skills. Apply lab experiments to real-world scenarios (q12)
It familiarises us with the **'real' science world** and shows us what will be expected of us in the future. (q12)	Most work-relevant and **real-life** applications (q8)	Another skill to include on your cv which is different to what other universities offer. Management skills. Problem-solving skills. Encourages you to adapt your learning to a **real-life scenario** (q12)
Applying to business model. More **realistic** as future will involve working with business and not just scientists (q12)	It relates to the **real world** and requires a less scientific style of writing and referencing than usual assignments (q8)	It is a **real-world problem**, that as a scientist I may encounter in future (q12)
Easy to link to **real-world scenarios** where these would be useful. Gives a more interesting challenge – broaden writing skills. Much easier to receive help and advice when being assessed in this way (q8)	It allows you to apply the knowledge obtained to future jobs and career options. (q8)	It requires us to apply ourselves in a **real-world scenario**, I like how it prepares us for a career in industry rather than how most assessments always seem to be preparing us for further research (probably to encourage more people to take up Master's courses) (q12)
Makes you think in a different way as compared to standard coursework. e.g. puts the theory in a **real-life scenario** (q12)	it is more fun putting it into a **real-world context** (q8)	

Some of the students became particularly immersed in the consultancy tender/real-world scenario, and invented their own company logos, manifestos and positions within a company (even though this was not a requirement of the assessment), as well as created mock-up mobile phone applications (SI Figure S2). Although not all students added these elements to their assessment submission, it suggests that for some students the real-world nature of the assessment added greater authenticity (McDowell and Sambell 1999) and resulted in enhanced engagement with the assessment task.

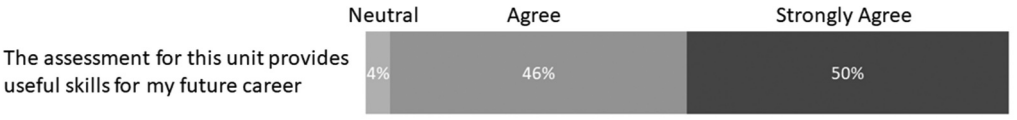
Skills development and employability

If authentic assessments are defined as being work-relevant and authentic, as well as meaningful and realistic, they should have value beyond education, in that the skills, techniques and approaches used should be relevant to employability. A number of researchers have pointed out that employers are concerned by the lack of employability skills exhibited by entry-level job applications (e.g. Cassidy 2006), and there is a growing awareness and desire for science, technology, engineering and mathematics (STEM) teaching to have pedagogies for employability built in (Bennett et al. 2020). Employers are looking to hire highly skilled graduates, and it is no longer enough for a new graduate to have knowledge of an academic subject; instead, students must gain skills to enhance their prospects of employment (Fallows and Steven 2000). Carefully designed authentic assessments can meet this need, by integrating skills development into the learning and assessment process, and assessing and teaching them alongside 'subject knowledge'. Thus, authentic assessments can be designed not only to assess what a student 'knows' but also what a student 'can do' with that knowledge, and how it can be applied in the real-world. It was a desired unit outcome that linking assessments to authentic real-world scenarios and having active learning embedded within the unit, would both enhance the skills gained in carrying out the unit and student awareness of having those skills.

To gauge students' awareness of whether they had gained skills, and enhanced their employability, students were asked if the assessment provided useful skills for their careers (Figure 3(a)), and were asked to describe the skills they had gained (Figure 3(b)). Students were aware of a significant upskilling through carrying out the unit. Ninety six percent of the 26 respondents felt that the assessment had given them useful skills for their future careers (Figure 3(a)), with just 4% neutral (1 respondent). An analysis of the free text responses (Figure 3(b)) showed that they could be categorised into two types of skills, here termed 'Employability Related' and 'Specific Skills'. The former was characterised by responses that referred directly to 'the workplace' or job opportunities and careers. The second category of comments regarding skills (classified under Specific Skills in Figure 3(b)) looked at skills that the students did not explicitly relate to employability or the workplace (but can nevertheless be used for employability). These skills include problem-solving, research, and communication, which can also be applied to further academic research or employment within industry. It is possible that the students who did not mention employability/workplace may be thinking more about going on to further research/study following their degree, although with the available data, it is not possible to ascertain this definitively.

The results from this study suggest that, by adopting the authentic assessment approach and its characteristic real-world scenario, we can help ensure that employability and real-world skills are provided to the students, by having employability skills built into our pedagogical approach (Bennett et al. 2020). The evidence provided here strongly suggests that the active lab-based learning approach, and the real-world assessment scenario, have provided the students with a skill set beyond just knowledge of the subject, and importantly, that the students are aware that they have these employability skills, which can provide the foundation for increased confidence in both applying for jobs, and when employed within a future career. Taken together with the development of 'real-world awareness', the above analysis of 'skills' shows that over half of the students were aware of the assessments' real-world applicability, and relevance to work/employment. The use of an authentic assessment

a)



b)

Employability Related	Specific Skills
What **future employers** expect from us how to write a tender	Provides **critical thinking** skills, trial an error in improving own practical designs, skills into how a scientist would think and work around problems.
Ability to apply for **future job opportunities**	**Problem Solving**. Research ability. Application (lab to public uses)
It prepares you for similar topics in the **workplace**	Another skill to include on your cv which is different to what other universities offer. **Management skills**. **Problem solving** skills. Encourages you to adapt you learning to a real life scenario.
Ability to persuade and sell, and my **career goal** is industry where IVD products need external approval, so I think these skills would help hugely.	The skills required to sell an idea
We can learn practical skills useful for our **future careers**	It is an exercise in **science communication** for a lay audience, which is a vital skill for all scientists
Necessary laboratory experience to be able to go further into education or progress into the **workplace**	I think it gives skills to write to different audiences and have a different point of view.
We can say that we've answered a tender before	**Trouble Shooting**. Learn different **writing skills**. Apply lab experiments to real world scenarios

Figure 3. (a) Likert data from the student questionnaire showing that 96% of the 26 respondents felt that the unit had given them useful skills for their future career, with 4% (1 respondent neutral). (b) Free text comments relating to what students perceived as the type of skill that carrying out the assessment provides, where students referred to key skills they have been highlighted.

has thus enhanced student awareness of the knowledge and skills they have gained, and their applicability for the solving of real-world problems, and enhanced student confidence and employment prospects.

Achievement

The mean unit mark was 68% (Figure 4(a)). However, marks were not normally distributed, and followed a bimodal distribution, with student marks typically clustered around 80–90% (high 1st class degree) and 50–70% (second class degree). This suggests that students who understood the unit and its assessment and were engaged, performed very well, while students who were less engaged remained in the second-class degree category. This suggests that the nature of authentic, and active learning employed in the 'Frontiers in Biotechnology' unit may result in a greater differentiation between students who perform well, and those that perform less well, when compared to a more conventional assessment and teaching approach.

The field of biotechnology is large, and the material taught only touched on a very small subset of biotechnology knowledge and applications, though each subject was studied in depth, with active learning approaches via significant laboratory exercises. The approach taken here was not to try and teach the whole of biotechnology, or even a large subset, as a collection of knowledge or facts to remember/understand, but to choose three carefully chosen subject areas (that reflect the research interests of the staff), and teach students more about how to use, manage, and apply the knowledge, rather than simply remember or recall it. There was thus a shift in focus from merely knowing the subject to knowing a subject and applying it, and teaching less material, but teaching that material in a better, more engaging way. The skills learnt in the unit can then be applied to any other area of biotechnology that the student learns about in future, whether in a research career, or in employment.

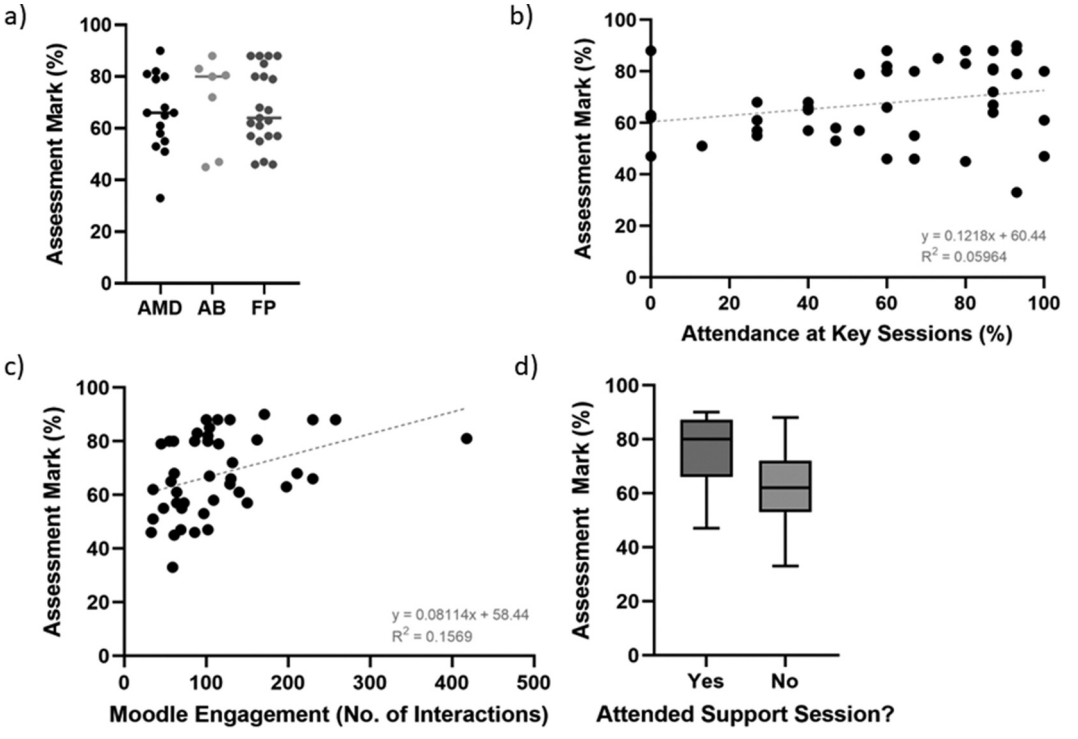


Figure 4. (a) Distribution of marks showing student achievement for the consultancy tender. Marks are shown for each mini-project. Individual student marks are represented by each point, with the median mark indicated as a solid line, the dashed line represents the mark required to achieve a first-class grade, (b) relationship between attendance at key lab and lecture sessions and assessment mark, (c) relationship between Moodle online engagement and assessment mark and (d) box plot of student unit mark, grouped by those attending the drop-in support sessions ($n = 16$), and those that did not attend ($n = 27$). Boxes represent the 25th and 75th quartile ranges, with the black square representing the mean unit mark, and the horizontal bar representing the median unit mark.

Attendance and its relationship to achievement

Authentic and innovative assessments can change the nature of student engagement or participation. When coupled with active learning, as in the design for this unit, high attendance may be more important for achieving a high mark, as it is more difficult to catch up on actively learnt material through simply viewing the lecture slides and remembering the material. Labs and active learning require interaction, and both lab sessions and taught sessions involve discussion and interaction with the teaching staff. It was expected, and hoped, that the increased focus on active learning and laboratory-based learning would lead to an enhanced desire on the part of the students to attend. However, many students had poor attendance, despite the nature of the assessment and the increased emphasis on face-to-face learning. Attendance on the course ranged from 0% to 100%, with a median of 60%. (SI Figure S3a). There was a progressive increase in absences as the course progressed, and this was particularly noticeable for those whose final mark was below a 1st (<70%). Students whose final mark was high (>70%) tended to have more consistent attendance throughout the unit (SI Figure S3b).

Much of the current literature shows a significant correlation between attendance and attainment at university (e.g. Clark et al. 2011; Credé, Roch, and Kieszczynka 2010; Kassarnig et al. 2017). However, some authors do not find a significant relationship (e.g. Eisen et al. 2015), while Halpern (2007) notes that few studies found a positive relationship between attendance and achievement test causality and that those who attend are likely to achieve as a result of pre-existing factors such as

entry qualification, age or cultural background. However, much of the literature is related to traditional forms of teaching (the lecture) and traditional forms of assessment (exams and essays). For example, Clark et al. (2011) quote students as saying that attendance at lectures is more important for exams, while for essays attendance is less important as it involves wider reading around the subject, whereas exams are more about what you need to know, and lectures are a way of learning that. The relationship between attendance and mark, with alternative assessment approaches, such as authentic assessments, may be different, particularly as fulfilling the criteria of the authentic assessment, and engaging with the active learning approach, places a greater onus on attendance, increased staff-student interaction and continuing learning support (Sambell, McDowell, and Montgomery 2012). However, in this study, there was no linear relationship between attendance at key taught sessions (i.e. not including support drop-in sessions) and marks (R^2= .06, $p > 0.05$) (Figure 4(b)) though the data does suggest that an attendance of > 50% is required for a 1st class mark.

Some students had zero attendance at taught sessions but did pass the unit, in one instance with a very high grade of 88%. However, attendance at face-to-face taught sessions was not the only way to engage with the unit material. Large amounts of material were provided via an online learning platform (Moodle), including lecture capture of the lecture sessions, as well as provision of the laboratory class results, and supporting videos, so students were able to engage with the course remotely. Figure 4(c) shows the relationship between Moodle engagement and unit marks. All students had Moodle interactions, with the majority having between 50 and 150 interactions over the course of the unit. Unlike attendance, there was a significant relationship ($R^2 = 0.16$, $p < 0.05$) between Moodle interactions and unit mark, suggesting that online activity and engagement are important in achieving high marks and that unit engagement does not necessarily require full attendance. However, the R^2 value suggests that just 16% of the variability in marks can be attributed to Moodle engagement, suggesting that student marks are related to a variety of factors beyond the scope of the present investigation. Interestingly there was no relationship between online activity and attendance at taught sessions (SI Figure S4). It may be expected that students who attend less may consequently have more Moodle interactions; however, this was not the case, with online activity being relatively consistent across students. However, the data do not indicate the types of interactions. As Büchele (2021) said about taught classes, the same can apply to Moodle, in that it is not about if they interacted with online material, but how they interacted with it. With the data available for this study, it is not possible to determine how students interacted within Moodle, and more interactions may not necessarily be more valuable to a student than a small number of targeted, focused interactions.

In addition to the core lab and lecture sessions, at the end of the unit (week 6) there was an additional drop-in assessment support in week 6. Of the 43 participants in the unit, 16 attended and 27 did not (Figure 4(d)) with those who did attend receiving an average mark of 76.2%, which was significantly higher (Mann Whitney test, $p = 0.004$) than those who did not, who averaged 62.6%. However, as Halpern (2007) states, it is often difficult to establish causality in attendance v marks studies, in that it is difficult to say if attendance at the assessment support session results in a higher grade, or if the students who were already likely to get a higher grade were more likely to attend. However, the data do suggest that engagement does have an impact on grades, though the relationship between attendance, engagement, and mark is complex, and will reflect many more factors that were not accounted for in this study.

Final thoughts

Overall, this unit adopted a design and approach that centred active learning, with a largely laboratory and research-based approach, coupled with an innovative and authentic assessment. Although the approach differed from the teaching and assessment approaches the students (and staff) were typically used to, the unit received high satisfaction from students, and met a number of

pedagogical and university strategic goals through the provision of a high-quality learning experience, while enhancing student knowledge and providing students with a strong skill set for their future careers. Although this study was concerned with a particular unit, and a single cohort of students, the approach to unit design, learning approaches and innovative assessment is applicable not only within biology but could also be adopted in units and programmes more widely. However, the data presented here is from a single run of a unit, with a limited sample set, concerning 43 students, with feedback (via questionnaire) from 26 students so the positive attitudes presented here may not be representative of the broader student population, or of student responses in other units, subjects or disciplines within higher education. Student feedback was carried out as the unit was being taught, and the student responses therefore reflect their thoughts and attitudes at that time and may not capture longer-term impacts and benefits of the authentic assessment approach on student learning and skill development.

Within the context of this Biotechnology unit, however, the data presented here strongly suggest that the adoption of a new and innovative assessment approach, coupled to active lab-based teaching, has several advantages over traditional teaching approaches and assessment types. Students declared themselves to be highly satisfied, highly engaged, and appreciative of the skills and employability insights the unit provided. It is recommended that consideration should be given to the adoption of authentic assessment approaches more widely, to provide an improved, engaging, satisfying, and rewarding student learning experience.

Acknowledgements

Special thanks to Dr Bernard Lisewski and Dr Stephen Powell from the University Teaching Academy at Manchester Metropolitan University for fruitful, engaging and informative discussions about active learning and authentic assessments. Thanks also to all the students who took part in the unit.

Disclosure statement

No potential conflict of interest was reported by the author(s).

ORCID

Andrew P. Dean http://orcid.org/0000-0001-6893-5118
James Redfern http://orcid.org/0000-0003-0958-683X
Kirsty J. Shaw http://orcid.org/0000-0001-9241-4195

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