

From fear to fascination: A single practical session improves students' attitudes towards insects, insect conservation and future entomological studies

O ddychryn i ddiddordeb: Un sesiwn ymarferol yn gwella agweddau myfyrwyr tuag at bryfed, cadwraeth pryfed, ac astudiaethau entomolegol yn y dyfodol

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Abstract

1. Insects dominate global biodiversity and play essential roles in ecosystem functioning; however, they remain underrepresented in conservation priorities despite widespread evidence of population declines. A key reason is the prevalence of negative attitudes towards insects (fear, disgust or disinterest), which limits public support for insect conservation and reduces the likelihood that students will pursue entomological careers. This contributes to both a shortfall in conservation funding and a shortage of taxonomic and ecological expertise. Identifying interventions that improve attitudes towards insects may therefore support both conservation outcomes and capacity building within the discipline.
2. Here, I investigate the impact of a single insect practical session on undergraduate biology students' attitudes towards insects and insect conservation. To assess changes in attitudes, students completed three questionnaires administered before and after traditional lectures, and after a practical session involving direct interaction with live and preserved insects.
3. I found that while lectures significantly improved student self-efficacy, they had little effect on attitudes towards insects. In contrast, the practical session not only enhanced self-efficacy but also positively shifted attitudes towards insects, increasing appreciation for insect conservation, and interest in studying insects further.
4. These findings suggest that brief, hands-on experiences with insects may provide a simple and scalable way to improve conservation-relevant perceptions of insects

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and inspire students to pursue entomology, helping to address critical workforce shortages needed to tackle global insect declines.

Cymraeg

1. Mae pryfed yn dominyddu bioamrywiaeth fyd-eang ac yn chwarae rhan hanfodol yng ngweithrediad ecosystemau, ond maent yn parhau i gael eu diystyru mewn blaenoriaethau cadwraeth er gwaethaf tystiolaeth eang o ostyngiad yn eu poblogaeth. Un rheswm allweddol yw pa mor gyffredin yw agweddau negyddol tuag at bryfed (ofn, ffieidd-dod neu ddiffyg diddordeb) sy'n cyfyngu ar gefnogaeth y cyhoedd i gadwraeth pryfed ac yn lleihau'r tebygolrwydd y bydd myfyrwyr yn mynd i weithio ym maes entomoleg. Mae hyn yn cyfrannu at ddiffyg cyllid i gadwraeth a phrinder arbenigedd tacsonomaidd ac ecolegol. Felly, gall nodi ymyriadau sy'n gwella agweddau tuag at bryfed gefnogi canlyniadau cadwraeth a meithrin capasiti o fewn y ddisgyblaeth.
2. Yma, rwy'n ymchwilio i effaith un sesiwn ymarferol am bryfed ar agweddau myfyrwyr bioleg israddedig tuag at bryfed a chadwraeth pryfed. Er mwyn asesu newidiau mewn agweddau, cwblhaodd myfyrwyr dri holiadur a roddwyd cyn ac ar ôl darlithoedd traddodiadol, ac ar ôl sesiwn ymarferol a oedd yn cynnwys rhyngweithio uniongyrchol â phryfed byw a sbesimenau.
3. Er bod y darlithoedd yn effeithio'n sylweddol ar hunaneffeithiolrwydd myfyrwyr, nid oeddent yn cael llawer o effaith ar eu hagwedd at bryfed. I'r gwrthwyneb, bu i'r sesiwn ymarferol wella hunaneffeithiolrwydd y myfyrwyr, a rhoddodd hefyd agwedd fwy cadarnhaol i fyfyrwyr tuag at bryfed, gan gynyddu eu gwerthfawrogiad o gadwraeth pryfed a'u diddordeb mewn astudio pryfed ymhellach.
4. Mae'r canfyddiadau hyn yn awgrymu y gallai profiadau byr, ymarferol gyda phryfed fod yn ffordd syml ac addasadwy o wella canfyddiadau perthnasol i gadwraeth pryfed ac ysbrydoli myfyrwyr i astudio entomoleg, gan gyfrannu at leihau'r prinder gweithwyr sy'n angenrheidiol i fynd i'r afael â dirywiad pryfed yn fyd-eang.

KEYWORDS

entomology education, insect conservation, practical learning, student attitudes

INTRODUCTION

Entomology is vital for addressing many of the challenges that face our world, including biodiversity declines (Goulson, 2019; Kehoe et al., 2021; Wagner, 2020), food production (Klein et al., 2007; Turo et al., 2024; van Huis, 2013) and control of vector-borne diseases (Kilpatrick & Randolph, 2012; Wilson et al., 2020), due to the key roles of insects in many ecosystems (Losey & Vaughan, 2006; Noriega & Schowalter, 2024). Despite this, insects are greatly understudied due in large part to the disparity between the vast number of insect species and the relatively small number of trained entomologists (Leather, 2009; Luke et al., 2023; Troudet et al., 2017). This shortfall limits our ability to gain from the benefits insects provide and to mitigate the risks they pose.

The reasons someone chooses to study and work in a particular discipline are complex (Akkermans et al., 2015; Felaco et al., 2023), however, a key driver is that of the attitude a person has towards a particular subject. Attitude can be defined as feelings that a person

has about an object (including subject material), based on their knowledge and belief about that object (Kind et al., 2007). Such beliefs have a strong influence on the subjects students choose to pursue and engage with (Osborne et al., 2003). This phenomenon is often discussed in terms of declining interest in STEM subjects in high school (Hamlyn et al., 2020; Hamlyn et al., 2024) and high attrition rates of students enrolled in STEM subjects at university (Sithole et al., 2017). The same is also true within scientific disciplines. For instance, many students have fears or disinterest in particular fields such as more quantitative areas (Ahmed, 2018; Hamlyn et al., 2020) or studies of unpopular taxa (e.g., insects, spiders, etc.) (Bebbington, 2005; Leather, 2009; Prokop & Fančovičová, 2017; Schlegel & Rupf, 2010). This leads students to avoid some topics, which in turn leads to gaps of expertise and competence in the scientific workforce and thus our knowledge (Bonnet et al., 2002; Troudet et al., 2017).

One of the barriers to pursuing entomological studies is that insects produce feelings of disgust or fear in many people (Fukano &

Soga, 2021; Lorenz et al., 2014), meaning that addressing this may be an important step to reduce the shortfall in trained entomologists (Luke et al., 2023). Pedagogical work over the last three decades has shown that the incorporation of active learning sessions (where students engage with material through discussions, problem solving and collaborative work) can aid student learning and outcomes (da Silva et al., 2008; Freeman et al., 2014; Gonsalvez et al., 2015; Prince, 2004), though little is known about how such sessions may influence student attitudes towards choosing specific subject material. Such active learning sessions may help to promote a positive attitude towards insects, as previous work has shown that feelings of disgust or fear of insects can be reduced in children by allowing them to handle insects for themselves (Prokop & Fančovičová, 2017). This suggests that the incorporation of hands-on active learning sessions with traditional lectures may help encourage students to study insects.

While encouraging students into neglected areas for work and study is an important goal, any education in the biological sciences should aim to have effects on a student's attitude beyond their studies and future work. For instance, while we are currently in the midst of a biodiversity crisis (IPBES, 2019), we are also seeing a strong decline in people's appreciation of nature (Beery et al., 2023). How connected people feel to nature is strongly related to how positive they feel towards conservation (Barrows et al., 2022; Lokhorst et al., 2014; Pocock et al., 2023; Richardson et al., 2020), meaning improving people's connection to nature is important to meet the needs of conservation. Insects are extremely important to the environment due to the ecosystem services they provide, yet they receive only around 10% of conservation funding (Cardoso et al., 2011) despite the well-documented and publicised declines of many important insects (Dicks et al., 2021; Goulson, 2019; Wagner, 2020; Wagner et al., 2021). The reasons for this funding shortfall are complex, however, as a person's attitude is also influential in determining which groups they are willing to conserve (Knight, 2008), a lack of connection or fear of insects is likely to impact insect conservation funding. As such, promoting a more positive attitude towards insects in bioscience students is thus important to reduce the shortfall in trained entomologists and to help to change the perception and conservation priorities of the public (Fukano & Soga, 2021; Luke et al., 2023; Troudet et al., 2017).

The aims of this study are to use questionnaires to examine how lectures and a practical session influence students' attitudes towards insects, and how they influence students' knowledge of insects both in terms of self-efficacy and on an insect-related test. I predict that while both the lectures and the practical session will increase students' knowledge of insects, only the practical session will be effective at improving the students' attitudes towards insects.

MATERIALS AND METHODS

Questionnaire design and data collection

I carried out three anonymous questionnaires with two cohorts (Autumn 2023 and Autumn 2024) of first-year biology and zoology

undergraduate students at Bangor University in the UK. The first questionnaire was given prior to any lectures on insects, the second following three insect lectures and the third following an insect practical session. The insect lectures were given as part of the Organismal Diversity module, a compulsory module for biology and zoology students which aims to give students an overview of the major groups of organisms. The insect lectures consisted of three 45-min lectures focusing on the diversity of insects, order-level taxonomy and the key morphological and physiological features of insects. Lectures were delivered in-person in a lecture theatre over the span of a week. The practical session was then given the following week as part of the Practical Skills module (also compulsory module for biology and zoology students) and consisted of allowing students to interact in groups with a range of live and pinned insects from each of the major insect orders, allowing students to examine various aspects of insect biology (e.g., mouthpart morphology, insect behaviour, etc.) for three hours. Students were directed to examine various aspects of insect biology via a handout with a mix of closed (e.g., Which order do the insects on this bench belong to? How can you tell?) and open-ended (e.g., Each of the insects has a similar colouration pattern. What do you think the role of it is?) questions to promote discussion between themselves, the demonstrators and myself. Students were told to complete the handout, but it was unassessed and only checked briefly by a demonstrator at the end of the session to allow students to check their answers. Note that due to the size of the class the practical session was run four times over two days in 2023 and three times over two days in 2024. Note which of the three or four practical sessions each questionnaire was completed in was not recorded.

Questionnaires were designed to test the influence of the lectures and practical on students' attitudes towards the importance of insects in general (Q1, Q2, Table 1), the importance of insects towards their own studies (Q3, Q4, Q5, Table 1), their attitude towards insects (Q6, Q7, Q8, Q9, Table 1) and their self-efficacy with respect to insect biology (Q10, Q11, Table 1). The questionnaire following the practical session also had two additional questions to examine the students' feelings towards the practical (Q12, Q13, Table 1). Students were asked to respond to each question on a 5-point Likert scale with the following options: strongly disagree, disagree, neutral, agree and strongly agree. Each questionnaire also included two demographic questions so that I could compare responses across groups of students and a free comment section where students could provide any other feedback they wished. Note the free comments were not analysed in this study but are available (see Data availability statement).

Paper copies of the first questionnaire were given out immediately prior to the first lecture on insects. Students were given 10–15 min to fill in the questionnaire before it was collected. Students were then given the three lectures on insects and then were given another copy of the questionnaire to fill out following the last lecture. The final questionnaire was given out as the final page of the handout for the insect practical sessions. Students were informed to fill in the questionnaire once they had finished the work in the handout. Questionnaires were then collected for processing.

All collected questionnaires were scanned using a Sharp MX-5071 photocopier. Scores and information were then copied

TABLE 1 Questions given to students in each of the questionnaires.

Question number	Question	Rationale
Q1	An understanding of insects is important for life scientists.	General importance
Q2	Understanding insects has important practical applications.	General importance
Q3	It is important that I improve my understanding of insects during my degree.	Importance to own studies
Q4	Understanding insects will help me get a job after I graduate.	Importance to own studies
Q5	I would like to study insects for my final year project.	Importance to own studies
Q6	Insects are disgusting.	Attitude towards insects
Q7	I am afraid of insects.	Attitude towards insects
Q8	Insects are boring.	Attitude towards insects
Q9	Insect conservation is important.	Attitude towards insects
Q10	I am comfortable identifying insects to an order level.	Self-efficacy
Q11	I can describe the anatomy of insects well.	Self-efficacy
Q12	The practical session helped me to better understand insects.	Influence of the practical
Q13	The practical session made me less afraid of insects.	Influence of the practical
Q14	Which degree course are you studying?	Demographic tracking
Q15	Which gender do you identify as?	Demographic tracking
Q16	Any other comments?	Qualitative feedback

Note: Q12 and Q13 were only asked in the questionnaire following the practical session.

manually from the scans into a spreadsheet. Answers for questions where students had either not selected an answer (27/12891) or selected multiple scores were discarded (18/12891). Following transcription, all recorded information was reviewed by a single person and then spot-checked for any copying errors.

Exam data collection

As part of the Organismal Diversity course, students were assessed with four multiple-choice question (MCQ) tests spread throughout

the semester (each worth 15% of the module grade), each focused on a particular taxonomic group and a final multiple-choice test at the end of the course (worth 40% of the module grade). All tests were conducted online using Blackboard Ultra, and results were downloaded using the gradebook function. Students who did not attempt the MCQ test were given a zero. Results were obtained for the years 2022, 2023 and 2024 as although no questionnaires were provided in 2022, the insect practical was still conducted that year, allowing for its effect on grades to be examined.

Data analyses

All data processing and analyses were conducted using Python (v.3.9.6) and R (v. 4.3.1) (R Core Team, 2023) unless stated otherwise.

To analyse the questionnaire data responses were first transformed into numerical data as follows: strongly disagree = 1, disagree = 2, neutral = 3, agree = 4, strongly agree = 5. The influence of session (before lectures, after lectures and after the practical) on student responses was tested using ordinal logistic regression framework (using the Ordinal R package (v. 2025.12–29) (Christensen, 2025)) with score as the response variable and session as the predictor variable. Because questionnaires were completed anonymously, student identities could not be linked across different sessions. As this violates the assumption of independent observations (as most students will have completed questionnaires in more than one session) a Huber-White covariance matrix was calculated (using the Sandwich R package (v. 3.1–1) (Zeileis, 2006; Zeileis et al., 2020)) and applied to the ordinal logistic regression models to account for this unobserved clustering. Pairwise comparisons between each session were then performed using a Wald z-test to compared estimated marginal means (EMMs) with the R package emmeans (v. 2.0.2) (Lenth & Piaskowski, 2026) estimated from the ordinal logistic regression model described above. This resulted in a total of 33 pairwise comparisons from the 11 questions asked in each session. *p*-values from these pairwise comparisons were then corrected for multiple tests using Benjamini and Hochberg's algorithm (Benjamini & Hochberg, 1995) to give false discovery rate *p*-values (FDR). The effects of gender and cohort (year) were tested and adjusted in the same way but with the addition of an interaction term between session and gender or session and cohort to the ordinal logistic regression model (number of pairwise comparisons used to adjust for multiple tests was 35 for both gender and cohort). The significance of the interaction term or each question was determined using a Wald test and, corrected for multiple tests using Benjamini and Hochberg's algorithm (number of interaction *p*-values used to adjust for multiple tests was 11 for both gender and cohort). Questionnaire data was visualised as Likert plots using the 'HH' package (Heiberger, 2024) in R.

Exam results were combined with student attendance data to allow the effect of attending the practical on exam scores to be assessed. To analyse grades, differences between groups were tested using a Wilcoxon rank-sum test corrected for multiple tests using

Benjamini and Hochberg's algorithm. It is possible that the students that did not attend the practical sessions may have a generally lower (or higher) ability to score well on exams than students that did attend the practical, potentially introducing a bias in these analyses. To adjust for this issue scores for the insect MCQ (MCQ-C) were also analysed after either dividing the grade on MCQ-C by the average grade on the first two MCQs (before the practical session) or the overall grade for the module. The effect of attending the practical on the proportion of failing students was analysed using logistic regression with attendance of the practical, cohort, their interaction and if the student had failed the previous tests (MCQ-A and MCQ-B, coded as: failed both = 0, failed one = 1, failed neither = 2) as predictor variables. Significance of terms was determined with likelihood ratio tests using the drop1 function in R. Pairwise effects of attending the practical on the proportion of failing students for each year were determined using Fisher's exact tests for each test (MCQ-A, MCQ-B, MCQ-C and the exam). *p*-values from these pairwise comparisons were then corrected for multiple tests using Benjamini and Hochberg's algorithm.

Cohen's *d* effect sizes and their associated 95% bootstrapped confidence intervals (number of bootstraps = 5000) were calculated to evaluate group differences for the questionnaires and exam results using the R package rstatix (v. 0.7.3) (Kassambara, 2025).

RESULTS

A total of 1012 questionnaires were returned over the 2 years (Parker, 2026). Overall attendance of the lectures varied between 58% and 79% for the lectures and 83% and 89% for the practical sessions (Table S1). The response rate of questionnaires for attending students varied between 86% and 92% for the lectures and 82% and

91% for the practical sessions (Table S1). This shows that response rates were overall quite high and that response rates were similar for the lectures and the practical sessions. There was no significant effect of cohort for any question in any session ($FDR > 0.05$, Table S2), nor any significant cohort by session interactions ($FDR > 0.05$, Table S3) so questionnaire data from both years were analysed together.

The importance students placed on the study of insects increased following the practical session

Before the lectures and practical session most students agreed or strongly agreed that studying insects was important for life scientists (92.6%, Figure 1a). Lectures did not change the students' attitudes (Figure 1a, before lectures vs. after lectures: Cohen's $d = 0.08$, 95% CI $[-0.07, 0.24]$, $FDR = 0.364$), but the practical session did have a small effect, with students agreeing more strongly that studying insects is important for life scientists (97.2%) (Figure 1a, before lectures vs. after practical: Cohen's $d = 0.28$, 95% CI $[0.13-0.43]$, $FDR = 1.89 \times 10^{-3}$, after lectures vs. after practical: Cohen's $d = 0.20$, 95% CI $[0.05-0.34]$, $FDR = 0.031$). Similarly, before the lectures and practical session most students agreed or strongly agreed that understanding insects has important practical applications (83.4%, Figure 1b). Again, lectures did not change the students' attitudes (before lectures vs. after lectures: Cohen's $d = 0.10$, 95% CI $[-0.06, 0.26]$, $FDR = 0.350$), but the practical session did have a small effect, with students agreeing more strongly that studying insects has practical applications (94.0%) after the practical session than before the lectures (Figure 1b, before lectures vs. after practical: Cohen's $d = 0.27$, 95% CI $[0.13-0.42]$, $FDR = 4.31 \times 10^{-3}$, after lectures vs. after practical: Cohen's $d = 0.18$, 95% CI $[0.03-0.33]$, $FDR = 0.054$).

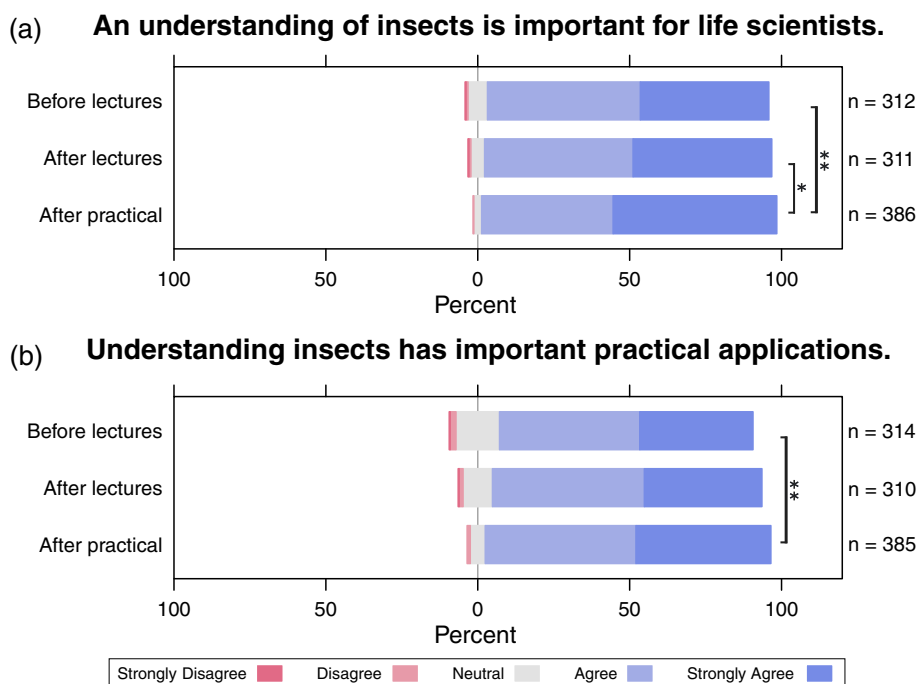


FIGURE 1 The attitudes students have towards the general importance of insects (Q1 and Q2) before lectures, after lectures and after the practical session. The bars show the percentage of responses in each category (strongly disagree in dark pink, disagree in pink, neutral in grey, agree in light blue and strongly agree in dark blue), centred around the neutral response. Significance levels (FDR) of Wald *z*-tests from estimated marginal means are indicated by asterisks as follows: *** < 0.001 ; ** < 0.01 ; * < 0.05 .

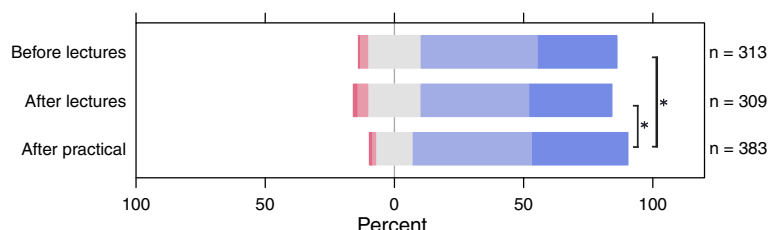
Students were more likely to want to study insects and placed more importance in understanding insects for their course after the practical session

Before lectures the majority of students agreed it was important to improve their understanding of insects during their course (agreed or strongly agreed = 75.7%, Figure 2a), but far fewer agreed that it would help them get a job (agreed or strongly agreed = 32.0%, Figure 2b), and even fewer wanted to study insects for their final year project (agreed or strongly agreed = 10.5%, Figure 2c). I found that the practical session, but not the lectures (FDR > 0.05, Table S4), resulted in a small increase in the importance students placed on understanding insects for their course. Following the practical session 83% agreed or strongly agreed it was important to improve their understanding of insects during their course (Figure 2a, before lectures vs. after practical: Cohen's $d = 0.18$, 95% CI [0.03–0.33], FDR = 0.027, after lectures vs. after practical: Cohen's $d = 0.21$, 95% CI [0.06–0.36], FDR = 0.023), 40% agreed or strongly agreed that it would help them get a job (Figure 2b, before lectures vs. after practical: Cohen's $d = 0.21$, 95% CI [0.06–0.37], FDR = 7.96×10^{-3} , after lectures vs. after practical: Cohen's $d = 0.20$, 95% CI [0.05–0.35], FDR = 0.021) and 21.2% agreed or strongly agreed that they would like to study insects for their final year project (Figure 2c, before lectures vs. after practical: Cohen's $d = 0.42$, 95% CI [0.27–0.58], FDR = 1.36×10^{-8} , after lectures vs. after practical: Cohen's $d = 0.29$, 95% CI [0.14–0.44], FDR = 5.64×10^{-4}).

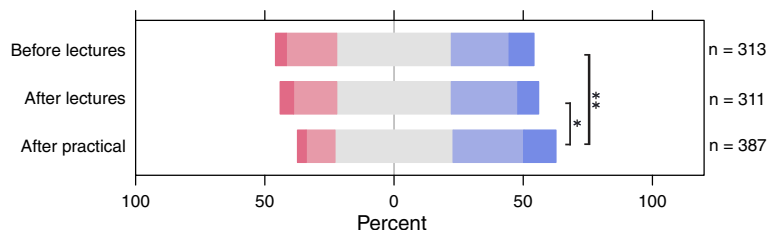
Students viewed insects and insect conservation more favourably after the practical session

Before the lectures and practical session most students viewed insects favourably, mostly disagreeing with the statements that insects are disgusting, that they were afraid of them, or that they are boring (disagree or strongly disagree = 72.8%, 69.3%, 73.0%, respectively, Figure 3). Note here a higher amount of disagreement indicates a more positive attitude towards insects. The practical session, but not the lectures (FDR > 0.05, Table S4), resulted in a small increase in this favourable attitude towards insects (disagree or strongly disagree = 81.7%, 77.7%, 89.9%, respectively, Figure 3, Q6 before lectures vs. after practical: Cohen's $d = -0.27$, 95% CI [−0.43 to −0.12], FDR = 3.94×10^{-4} , Q6 after lectures vs. after practical: Cohen's $d = -0.21$, 95% CI [−0.36 to −0.06], FDR = 8.96×10^{-3} , Q7 before lectures vs. after practical: Cohen's $d = -0.23$, 95% CI [−0.38 to −0.08], FDR = 2.28×10^{-3} , Q7 after lectures vs. after practical: Cohen's $d = -0.17$, 95% CI [−0.32 to −0.02], FDR = 0.044, Q8 before lectures vs. after practical: Cohen's $d = -0.45$, 95% CI [−0.60 to −0.30], FDR = 4.70×10^{-8} , Q8 after lectures vs. after practical: Cohen's $d = -0.30$, 95% CI [−0.45 to −0.15], FDR = 1.17×10^{-3}). Almost all students also agreed that insect conservation was important before the lecture and practical session (94.5%, Figure 3d). Despite this, the practical session still resulted in a small increase in the proportion of students who agreed that insect conservation was important when compared to before lectures (97.4%, Figure 3d,

(a) It is important that I improve my understanding of insects during my degree



(b) Understanding insects will help me get a job after I graduate.



(c) I would like to study insects for my final year project.

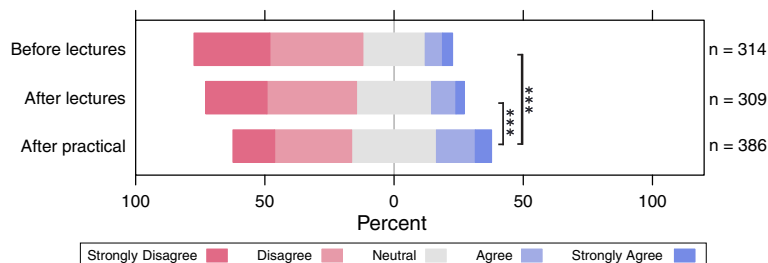


FIGURE 2 The attitudes students have towards the importance of insects towards their own studies (Q3, Q4 and Q5) before lectures, after lectures and after the practical session. The bars show the percentage of responses in each category (strongly disagree in dark pink, disagree in pink, neutral in grey, agree in light blue and strongly agree in dark blue), centred around the neutral response. Significance levels (FDR) of Wald z-tests from estimated marginal means are indicated by asterisks as follows: *** < 0.001; ** < 0.01; * < 0.05.

before lectures vs. after practical: Cohen's $d = 0.18$, 95% CI [0.03–0.33], FDR = 0.046).

Students' self-efficacy with insect taxonomy and anatomy increased after lectures and the practical session

Prior to the lectures and practical session few students agreed they felt comfortable identifying insects to an order level (agree or strongly agree = 17.3%, Figure 4a) or describing their anatomy (agree or strongly agree = 15.9%, Figure 4b). Following the lectures this percentage showed a moderate to large increase (to 38.6% and 53.1% respectively, Figure 4, Q10 before lectures vs. after practical: Cohen's $d = 0.64$, 95% CI [0.47–0.81], FDR = 7.40×10^{-14} , Q11 before

lectures vs. after practical: Cohen's $d = 0.94$, 95% CI [0.76–1.13], FDR = 8.82×10^{-27}). This percentage showed a further moderate increase following the practical session for taxonomy (to 65.9%, Figure 4, after lectures vs. after practical: Cohen's $d = 0.67$, 95% CI [0.52–0.83], FDR = 4.22×10^{-16}) but not anatomy (Figure 4, after lectures vs. after practical: Cohen's $d = 0.13$, 95% CI [–0.02 to 0.28], FDR = 0.350).

Students reported that the practical session improved their understanding and made them less afraid of insects

In agreement with the shifts seen between sessions, following the practical session the majority of students also reported the practical

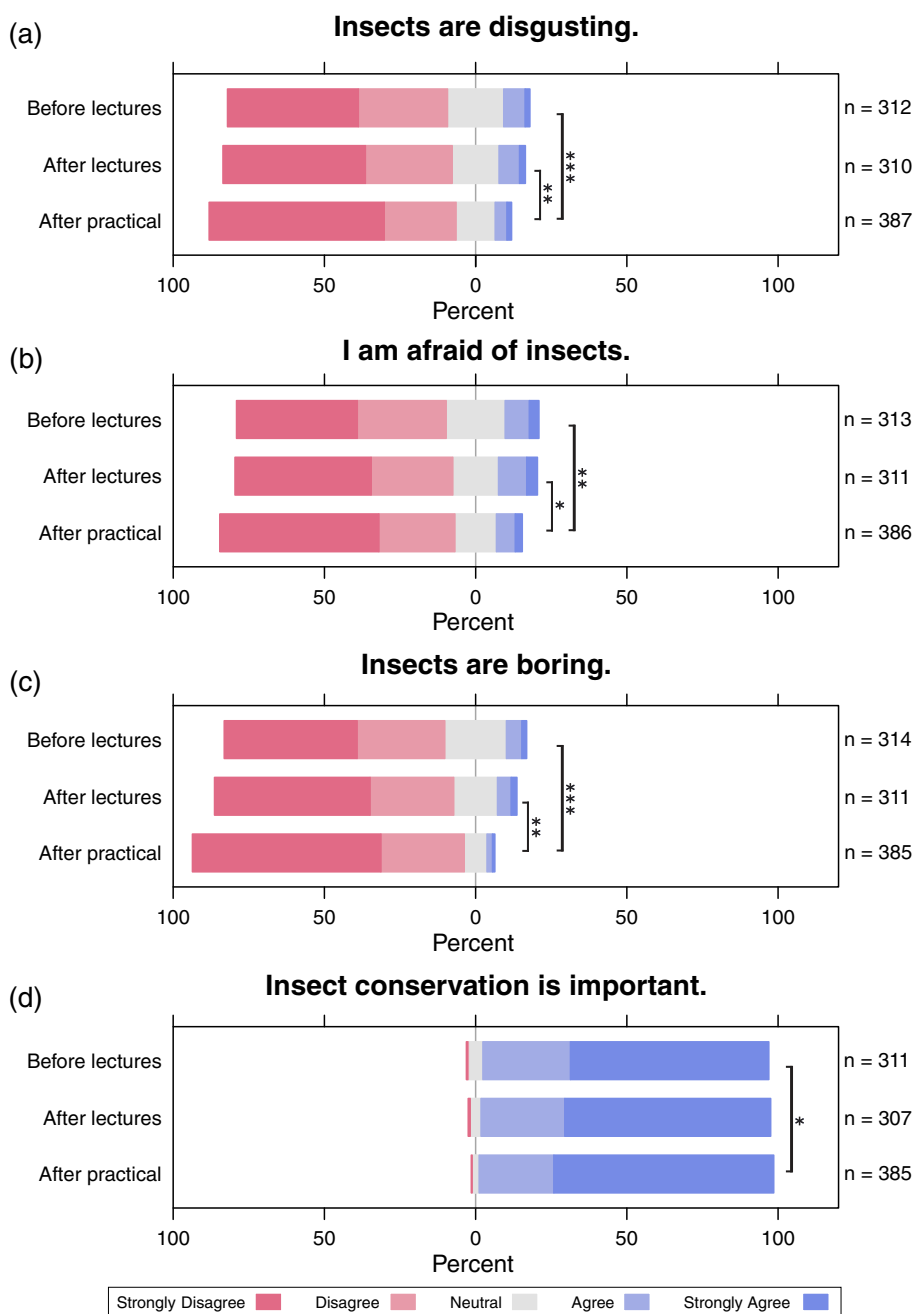


FIGURE 3 The attitudes students have towards the insects in general (Q6, Q7, Q8 and Q9) before lectures, after lectures and after the practical session. The bars show the percentage of responses in each category (strongly disagree in dark pink, disagree in pink, neutral in grey, agree in light blue and strongly agree in dark blue), centred around the neutral response. Note for Q6, Q7 and Q8 increased disagreement reflects a more positive attitude towards insects. Significance levels (FDR) of Wald z-tests from estimated marginal means are indicated by asterisks as follows: *** < 0.001; ** < 0.01; * < 0.05.

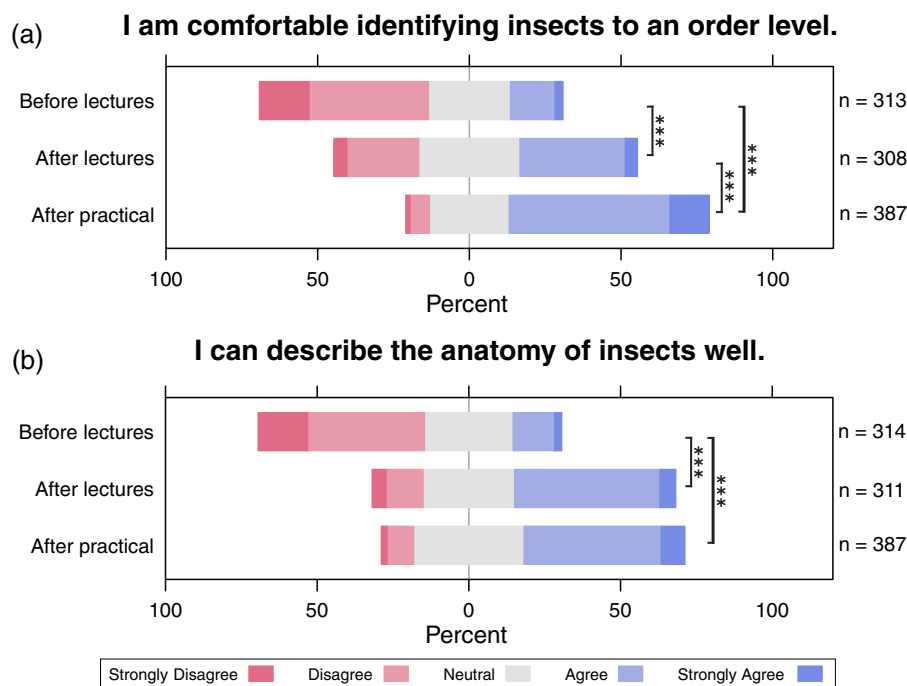


FIGURE 4 The attitudes students have towards their self-efficacy of insects (Q10 and Q11) before lectures, after lectures and after the practical session. The bars show the percentage of responses in each category (strongly disagree in dark pink, disagree in pink, neutral in grey, agree in light blue and strongly agree in dark blue), centred around the neutral response. Significance levels (FDR) of Wald z-tests from estimated marginal means are indicated by asterisks as follows: *** < 0.001; ** < 0.01; * < 0.05.

session helped them to better understand insects (96.6%, Figure 5a) and that it made them less afraid of insects (53.8%, Figure 5b).

Gender had little influence on students' attitudes to insects

Across the three questionnaires 94% of students chose to record their gender identity (952/1012). 95% (904/952) could be classed as either male students or female students (Table S5). The remaining responses (students not identifying as either male nor female, $n = 48$) were too varied and few to allow for quantitative analyses. For all but six comparisons, there were no differences in responses due to gender (FDR > 0.05, Table S6), showing that overall gender has little effect. For questions that did show a significant gender effect, all but one were related to the general attitude of students towards insects (Q6, Q7 and Q8, Table 1) showing that before lectures male students found insects less disgusting and less boring (Figure S1, Q6 before lectures: Cohen's $d = 0.42$, 95% CI [0.18–0.66], FDR = 0.015, Q8 before lectures: Cohen's $d = 0.41$, 95% CI [0.18–0.66], FDR = 0.008). Male students also reported they were less afraid of insects than female students before lectures, after lectures and after the practical (Figure S1, Q7 before lectures: Cohen's $d = 0.59$, 95% CI [0.36–0.83], FDR = 1.03×10^{-4} , after lectures: Cohen's $d = 0.45$, 95% CI [0.21–0.70], FDR = 0.005, after practical: Cohen's $d = 0.27$, 95% CI [0.06–0.5], FDR = 0.032). Male students were also slightly more likely to agree that they felt comfortable describing insect anatomy than female students before lectures (Figure S1, Q11 before lectures: Cohen's $d = -0.33$, 95% CI [–0.58 to –0.10], FDR = 0.033). Although most of these significant effects were found before the lectures (for Q6, Q8 and Q11) and were not found following the lectures

or practical, no gender by session interactions were significant for any question (FDR > 0.15, Table S7), meaning that the idea that lectures or the practical reduce gender biases is only weakly supported.

Practical attendance was associated with a lower fail rate but not a higher grade on a multiple-choice test

Students who attended the practical session did not perform differently on the insect MCQ test (MCQ-C) to students who did not attend the practical (Wilcoxon FDR > 0.9, Figure 6a), showing that the practical did not improve their attainment. This result remained when adjusting for student ability using either the final exam grade (Figure S2A) or the grades from the two MCQs that preceded the insect one (Figure S2B). In contrast, attendance of the practical session appears to reduce the likelihood of failure on the insect MCQ test in two out of the 3 years the practical ran (Figure 7c), but not on the MCQs that preceded the practical session (Figure 7a,b, examined as a control) nor the final exam (Figure 7d). This is supported by logistic regression approach which also found attendance of the practical session appears to reduce the likelihood of failure on the insect MCQ test (Figure 7c, Cohen's $d = -0.29$, 95% CI [–0.44 to –0.12], p -value = 0.013). This model also included an attendance by cohort effect, but this was not significant ($p = 0.072$), showing the attendance effect does not differ significantly between cohorts. Further investigation shows the reduced failure rate is driven mostly by a lower number of students not attempting the insect MCQ when they attended the practical session test (Figure S3, Cohen's $d = -0.27$, 95% CI [–0.41 to –0.09], p -value = 6.41×10^{-4}). This is also supported by the finding that there is no difference in failure rate between students that attended the practical and those that did not

FIGURE 5 Student opinion of the practical session. The bars show the percentage of responses in each category (strongly disagree in dark pink, disagree in pink, neutral in grey, agree in light blue and strongly agree in dark blue), centred around the neutral response.

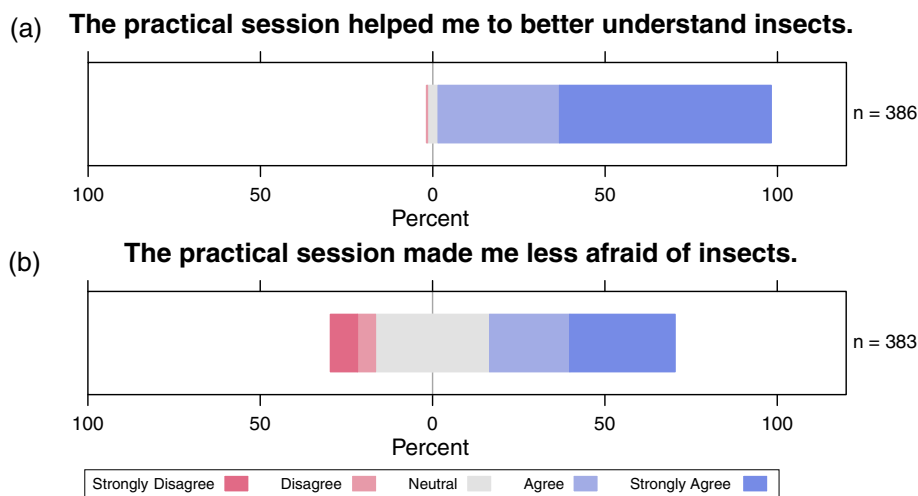
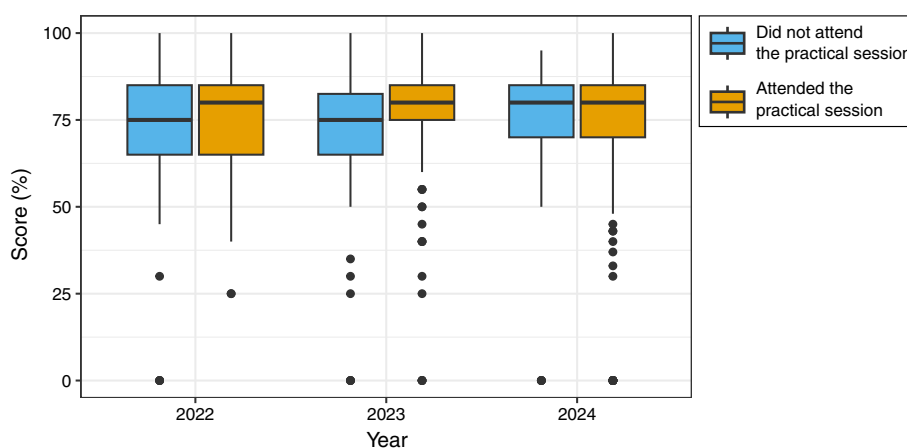


FIGURE 6 Student grades on the insect MCQ test (MCQ-C) for students that attended (orange) and did not attend (blue) the practical session. Note the practical session did not run in 2020 and 2021 (grey). Significance levels (FDR) of Wilcoxon tests are indicated by asterisks as follows: *** < 0.001; ** < 0.01; * < 0.05.



when non-attending students were excluded from the analysis ($p = 0.877$). This suggests that attendance of the practical may reduce failure rates by increasing the number of students attempting the MCQ test, suggesting the practical session may have increased student engagement.

Taken together, these results show that while both lectures and the practical session were associated with improved self-efficacy, the positive shifts in attitude towards insects shown here were only observed following the practical session.

DISCUSSION

Creating a positive attitude towards insects is essential to train the next generation of entomologists and to support the conservation of insect biodiversity. Here I show that the inclusion of a practical active learning session resulted in students having a more positive attitude towards insects as well as increased self-efficacy of this taxon. In contrast, although traditional lectures were effective at increasing students' self-efficacy towards insects, they had little effect on students' attitudes towards insects. The practical session was also associated with a reduction in the failure rate of the multiple-choice assessment because of more students attempting the test if they attended the

practical. As such, this study provides an example of how the addition of a single active learning session can be used to both create a more positive attitude towards insects and potentially to improve student engagement.

Overall, most of the students surveyed had positive views towards insects prior to the first lecture. This is likely because all the students in the study were already studying a bioscience discipline. Despite this, I still find the practical session produced repeated shifts towards a more favourable opinion of insects in terms of their overall importance, general opinion and towards their own studies. Such shifts in attitude should hopefully translate into a greater number of students pursuing studies of insects in the future, a taxon that is greatly understudied (Leather, 2009; Luke et al., 2023). This is because students are more likely to pursue and engage in disciplines for which they have a positive attitude (Osborne et al., 2003), and so, by increasing positive attitudes towards insects, more students are more likely to want to study entomology. The beginnings of this shift can be seen in this study, with an 11-percentage point increase in the number of students wanting to study insects for their final year project.

In addition to changes in attitude towards insects for their studies, I also found evidence that the practical session, but not the lectures, influenced attitudes about insects more generally, with students

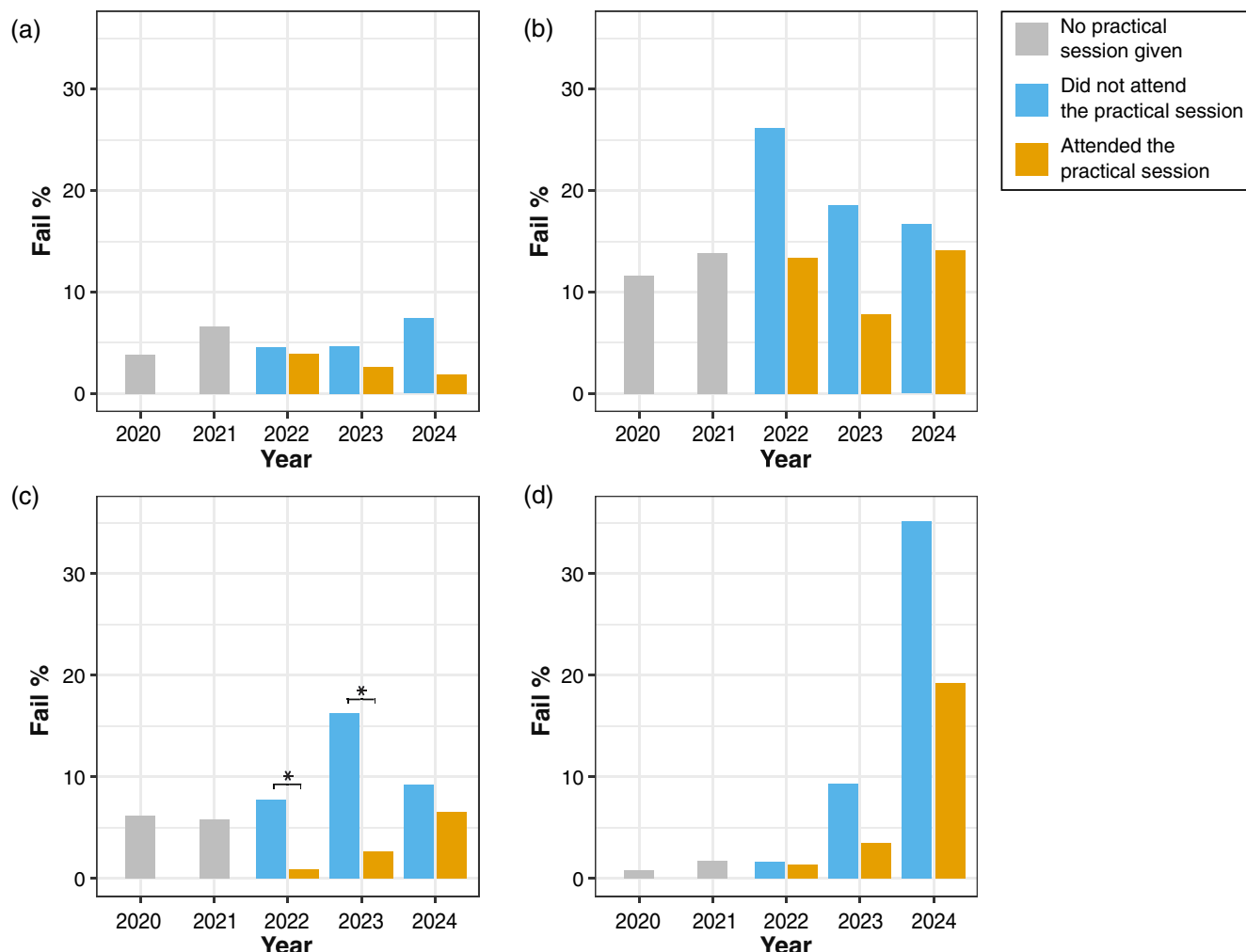


FIGURE 7 Percentage of students failing the MCQ tests for students that attended (orange) and did not attend (blue) the practical session. Note the practical session did not run in 2020 and 2021 (grey) and that the fails include students that did not attempt the MCQ test. a. MCQ-A which ran before the practical session, b. MCQ-B which ran before the practical session, c. MCQ-C the insect MCQ which ran after the practical session, d. Overall exam grade at the end of the module. Significance levels (FDR) of Fisher exact tests are indicated by asterisks as follows: *** < 0.001; ** < 0.01; * < 0.05.

reporting that they found them less boring, less disgusting and were less afraid of them after the practical session. This increased affinity for insects also coincided with a small increase in students agreeing that insect conservation is important. This finding should be treated with some caution, however, as almost all students placed a high importance on insect conservation before the lectures, meaning any additional increase in the importance students may gain from the practical or lectures were hard to estimate due to a ceiling effect for this question. Taken together, these results fit well with previous studies that have shown that handling insects can reduce negative feelings towards them (Prokop & Fančovičová, 2017) and that attitude has a strong influence on determining which taxa people want to conserve (Knight, 2008), showing how even small interventions can have important effects on the taxa chosen to be conserved. While important for bioscience students, this kind of kind of intervention may actually be more effective at changing the attitudes of the general public. This is because the students in this study already had a higher

affinity for insects than the public (Lorenz et al., 2014) prior to the practical meaning that there is less scope for additional improvement. Targeting the public may be more difficult than the students in this study for two reasons. Firstly, as the average perception of insects is much lower in the general population, the public may be more likely to avoid attending any such interventions. Secondly, as any intervention would not likely be related to their study or work, people may have less reasons to engage with it. The payoffs of such interventions however may be much greater as there is scope for a larger change in attitude as well as having a larger audience to target. Previous work has shown that a wide variety of outreach events have been successful at improving student attitudes across a wide range of topics (Crawford et al., 2021; Vennix et al., 2018), including entomology (Blevins, 2018; Mongue & Colyott, 2020), suggesting that attending such events would have a positive effect on the conservation of insects for students as well as other audiences (Lampert et al., 2024; Parker et al., 2019; Penn et al., 2018). The most effective type of

outreach event for the public would likely be a general outreach event that contained an insect handling component (e.g., general science show or gardening event) as this would mean people with more negative attitudes towards insects would be more likely to attend (though further study is needed to confirm this). An alternative approach would be to focus on children and introduce insect handling in the classroom or as part of citizen science projects (Howe et al., 2025; Miller et al., 2025). The benefit of this approach is that children are more likely to shift their attitudes than adults (Kelemen et al., 2023), meaning any interventions done with children would likely be more effective and potentially have longer-lasting impact. If such interventions are successful in increasing people's affinity for insects, this could provide a means of increasing public support for increased insect conservation funding, as people are more likely to support the conservation of taxa for which they have positive attitudes towards (Knight, 2008).

Overall, I found gender had little influence on student attitudes towards insects; however, I did find that for several questions, male students had a more positive attitude towards insects than female students. Most of these gender differences were prior to the lectures suggesting that learning about insects and/or handling insects may reduce this gender bias, however, as the overall effect sizes were small and there was no support for any gender by session interactions, this suggestion is not supported by this study.

One of the largest changes observed was a shift in self-efficacy, with both lectures and the practical significantly increasing the reported self-efficacy with insect taxonomy. These findings highlight how traditional lectures are an effective means of delivering information that can be enhanced through the addition of a practical session. This finding is in agreement with previous work highlighting the role of active learning and practical sessions on student self-efficacy (Aikens & Kulacki, 2023; Ballen et al., 2017; Hutchison et al., 2006). This increased self-efficacy is also partly reflected in student performance on a MCQ test. I found that although attendance of the practical session did not increase student grades, it did appear to reduce the failure rate, in line with previous work (Freeman et al., 2014). This decline was specific to the MCQ relating to insects and did not extend to the other MCQ tests that proceeded the practical (showing that the students who did not attend the practical were not more likely to fail in general), nor the overall exam. This effect appears to be driven by more students attempting the test if they attended the practical, suggesting that rather than improving attainment, the practical session may have improved student engagement instead.

While I did not observe an increase in overall exam grades for students attending the practical session, this may be because the average grade is already quite high (>75%) and the exam is a set of 20 multiple-choice questions meaning subtle effects may be difficult to detect. A previous meta-analysis of the effects of active learning showed the average increase in grades was around 6% (Freeman et al., 2014), which could be hard to discern from such a course metric. In addition, although there was an associated test on insects, the content of the practical was not directly assessed by the MCQ. Not tying the practical to the assessment may thus also contribute to the lack of an

increase in the overall grade, as it has been previously shown that direct assessment can be beneficial as it focuses student attention to what is important (Gibbs & Simpson, 2005; Hand et al., 1996; Kickert et al., 2022). The decision not to have a direct assessment of the practical here was done as the primary goal of the practical session was to spark student interest and create a more positive attitude towards insects. Not providing a direct assessment and instead giving students the freedom to explore the material as they wished may have thus allowed students to think more creatively about the material and thus engage with it more deeply (Choi et al., 2019) at the expense of an increase in overall grades, meaning that MCQ may also have been insensitive to practical-specific learning.

CONCLUSION

This study shows how adding an active learning practical session to traditional lectures was associated with a positive shift in student attitudes towards insects. Crucially, the practical session was associated with a reduction of negative attitudes towards insects, an increase in the importance students placed on insect conservation, an increase in the likelihood of students wanting to study insects in the future, stronger self-efficacy and a greater engagement with an insect-related assessment. This highlights how simple interventions may help to engage students with underrepresented taxa, supporting both the development of future specialists and potentially the broader conservation of insect biodiversity.

AUTHOR CONTRIBUTIONS

Darren J. Parker: Conceptualization; investigation; funding acquisition; writing – original draft; methodology; visualization; writing – review and editing; formal analysis; project administration; data curation.

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CONFLICT OF INTEREST STATEMENT

The author declares no potential conflicts of interest.

DATA AVAILABILITY STATEMENT

Data and code are archived in Zenodo available here: Parker (2026). Insect_practical_code. Zenodo; version 1; <https://doi.org/10.5281/zenodo.23084811>.

ETHICS STATEMENT

Ethical approval of this study was provided by the College of Science and Engineering Ethics Committee at Bangor University (Approval Number: CoSE2024DP01A).

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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