Field skills through a screen: Reflections on plant identification teaching during the COVID-19 pandemic

Sebastian Stroud
School of Biology, Faculty of Biological Sciences, University of Leeds

Abstract

Plant identification and ecology are often lacking in the curricula of life sciences programmes. However, for our University of Leeds MSc Biodiversity and Conservation students, it is a vital skill that industry holds in high regard due to the dearth of basic identification skills among many graduates. The COVID-19 pandemic made the possibility of running this module in person impossible. As such, I, as a graduate teaching assistant (GTA) developed an innovative and immersive online module that met the module's fieldwork requirements and learning objectives. By using online learning tools and activities such as interactive image boards, group workshops, and self-directed fieldwork, I led, designed, and delivered an online program of plant identification teaching.

Students were able to discuss and explore findings via several channels and seek guidance in tailored small-group sessions with myself and a colleague as dedicated GTA tutors. I interviewed six students who previously undertook the online plant identification module during the COVID-19 pandemic. Using a series of Likert scale questions and deductive thematic analysis, I reflect on the challenges and opportunities presented by the COVID-19 pandemic. Through the novel utilisation of online learning tools, this course can now better support our students in self-directed and peer-to-peer learning in botanical fieldwork and identification both online and in person. For the teaching of plant ecology, fieldwork will continue to be a staple in our educational toolbox. Results from interviews demonstrated students improved their awareness of plants and have retained and continued to develop plant knowledge. Novel tools such as distance learning technologies developed during the pandemic offer opportunities to enhance our learners' experience. Specifically, materials produced for online courses can be integrated into blended teaching approaches.

Introduction

Plant identification is often pruned from curricula of life sciences programmes, and many undergraduate biological science degrees in the UK may contain little plant biology content (Stroud et al., 2022). This is despite plants' vital contribution to society, culture, and the maintenance of our biosphere (Lev-Yadun et al., 2000). The teaching of ecology and plant biology is critical as a mechanism for understanding and curtailing the current and impending ecological and climate crises (Ruckelshaus et al., 2020; Steffen et al., 2015). Imparting students with a comprehensive understanding of botany and plant ecology is not simply the ability to correctly distinguish plants and recall specific species' ecology but a broad spectrum of understanding ranging from plant physiology, identification, taxonomy, ecology, and genetics to cellular plant biology. Botanical education should aim to impart this understanding of plants from form to function, physiology, and ecology, but also the role of plants within their social, economic, and cultural contexts (Stroud et al., 2022).

Within the UK, the last student enrolled on a bachelors botany degree was over a decade ago (Drea, 2011), whilst currently students in plant biology and science programmes are vastly outnumbered when compared to other bioscience programmes (Stroud et al., 2022). This trend of plant neglect in education is a symptom of a wider social and biological phenomenon that positions plants as the backdrop of life. Declines in plant knowledge have been documented across the globe, from the US as early as the 1960s (Godwin, 1968), to South Africa (Abrie, 2016), and Mexico (Saynes-Vásquez et al., 2016). This phenomenon was first formally identified in the research literature by US biologists and educators Wandersee and Schussler (1999), who titled the inability of a person to perceive plants in their environment, acknowledge their importance or appreciate their aesthetic and unique biological features as 'plant blindness'. It should be said, however, that this language places negative implications on those experiencing these phenomena and various alternative concepts such as fostering 'plant awareness' have been suggested (Bacon et al., 2021; Parsley, 2020).

Despite the lack of many university programmes offering comprehensive plant identification modules, at the University of Leeds, the BLGY5163M Plant Identification is a key component of the MSc Biodiversity and Conservation programme. This programme welcomes approximately 40 students annually from a variety of different backgrounds including those from arts and humanities. The module is centred around fieldwork spread over two weeks. The module was originally introduced after feedback was received from various conservation organisations, which highlighted that many of our graduates, whilst knowledgeable on ecological theory, lacked core skills in species identification, likely due to the extinction of botanical education within UK higher education (Stroud et al., 2022).

However, as with all in-person teaching, the COVID-19 pandemic and following national lockdowns made running this module in person impossible during the year 2020. In light of the pandemic, the transition to virtual teaching and learning represented a major challenge to those working within higher and environmental education, particularly given the extremely restricted timeline for teaching staff to make changes to their programmes (Bacon and Peacock, 2021). The result was that no in-person teaching was permitted at the University of Leeds for the remainder of the 2020/2021 academic year. The available options for remote teaching were via media delivery through the Virtual Learning Environment (specifically Minerva), Microsoft Teams or Zoom.

This left the teaching staff for the plant identification module in a dilemma, should they suspend the module for that current year, or radically redevelop the whole course to an online format? Knowing the significance of these skills from my research on botanical education, I believed that it was essential that this module still be delivered. Other graduate teaching assistants (GTAs) within the faculty and I felt we were able to support both student online learning and equip students with comparable plant identification skills. Additionally, I believed that the benefits of encouraging

students to spend time in nature and engage in outdoor activities such as plant surveying, might support their wellness and develop a sense of community during the pandemic.

It has been recognised that GTAs act as important contributors within higher education through their practice as assessors, tutorial leaders, and laboratory and field work demonstrators (Meadows et al., 2015). Within the context of this case study, the work of GTAs continues to be influential. I developed an innovative and immersive series of micro-lectures, practical sessions and workshops which met the fieldwork requirements and the module's learning objective: '*Identify the common UK plant families and species*'. By using a mixture of online learning tools and activities such as interactive image boards, pre-recorded micro-lectures, group forums, and self-directed COVID-19 secure fieldwork, students were able to discuss and explore findings via several channels and seek guidance in tailored small group sessions with GTAs. Before the module commenced, identification keys and magnifying hand lenses were sent to all students. From previous years I recognised that many students often wished to share their independent finds with the wider cohort; therefore, I also incorporated an online message board, Padlet, to facilitate this knowledge sharing.

I structured the module workshops around eight key plant families, which when combined cover a total of a third of the entire flora of the British Isles, to ensure that plenty of specimens would be available for workshops. These families were: *Brassicaceae* (cabbage), *Asteraceae* (daisy), *Fabaceae* (pea), *Apiaceae* (carrot), *Rosaceae* (rose), *Ranunculaceae* (buttercups), *Liliaceae* (lilies), and the *Geraniaceae* (geraniums). Each of these families' key identification features was discussed in an associated pre-recorded micro-lecture which students were asked to watch before the online interactive workshops (see Figure 1). The workshops were also focused on these respective key families alongside other key information on field botany, such as codes of practice and the ethics of collecting specimens. Students were directed to go into their local area and collect specimens which exhibited these key characteristics (Figure 1). These small group online workshops consisted of around five students, myself, and another GTA.

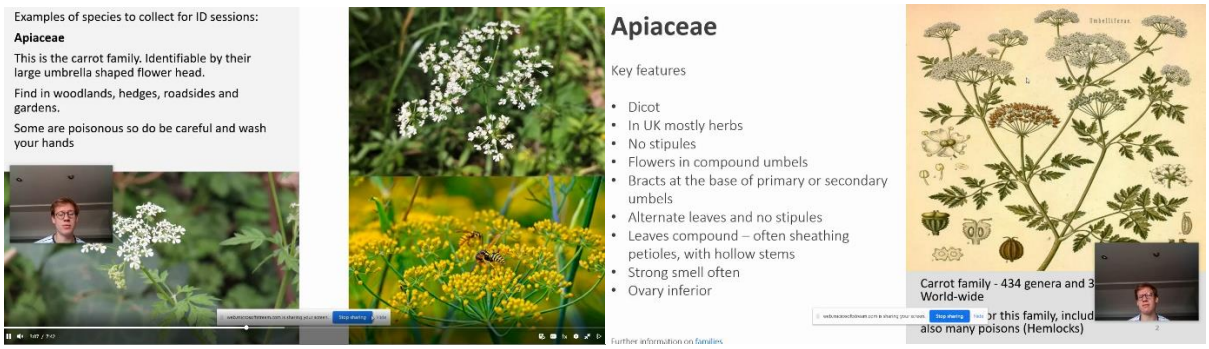

Figure 1: These small student online workshops were based on several key plant families, chosen to reflect broad coverage of plant species in the UK. Above is an example of one of many short micro-lectures detailing key family identification characteristics and providing examples of possible specimens students could collect for group sessions.

Aims and scope of this paper

As a postgraduate demonstrator and tutor, otherwise known as a Graduate Teaching Assistant (GTA), at the Faculty of Biological Sciences at the University of Leeds, I teach and lead various components of ecology and sustainability modules, including botanical field skills, plant ecology and urban green infrastructure. A primary aim that informs this teaching is to understand how to better equip today's students to combat the societal, environmental, and ecological challenges of the future using nature-based solutions of a botanical nature. As such, the scope of this paper is to explore different approaches to improve and innovate botanical pedagogy through an examination

of a university MSc botany module as a case study. The aim of this paper is 1) to report and reflect on students' experiences of plant identification module during the COVID-19 pandemic and the different online delivery methods used and 2) to discuss how their reflections can be implemented to improve future courses and teaching of undergraduate and postgraduate students.

Method

To meet the aims of this paper, eligible participants were students who have previously been enrolled on the postgraduate MSc Conservation programme during the COVID-19 pandemic and experienced online teaching of the plant identification module. This module takes place in May each year and is typically taught in practical workshops and field visits over two weeks. The module maintained the same structure and timetabling during the online teaching with online lectures in the morning (typically 1 hour), daily group workshops, and students' independent practical fieldwork in the afternoons.

To recruit these students, eligible individuals were contacted via LinkedIn, a professional networking platform, by requesting their participation in a short online interview. Of the 21 invitations extended, 14 (67%) students expressed an interest in being interviewed, with a final 6 (29%) students interviewed in total. Semi-structured interviews were conducted with the final sample by the author, in the autumn of 2022. Before interviews commenced participants were first presented with consent forms and a summary of the study aims; ethical approval was given by the Faculty of Biological Science Research Ethics Committee (Ethics reference: LTSBIO-042). In total, six 30-minute interviews were conducted with students who had previously undertaken the online plant identification component of this module; additionally, one of the students subsequently joined the module staff later in the next academic year to undertake fieldwork-based plant identification teaching.

I asked students to reflect on the challenges and opportunities presented by the COVID-19 pandemic, and if they felt supported in self-directed and peer-to-peer learning in botanical fieldwork and identification (both online and in-person). I also asked them to reflect on the use of online learning tools in the module. The module featured online resources such as an image board (PadLet, 2020), and encouraged the use of artificial intelligence (AI) based identification apps to explore plant diversity (PlantNet, PictureThis, GoogleLens), and pre-recorded micro-lectures (Figure 1). Interview guides were developed to capture student evaluations of these resources. The interviews also included a series of questions based on ranking responses on a 10-point Likert scale, which evaluated students' confidence in their ability to identify or notice various plant groups. These two vegetation groups were 1) *trees, shrubs, and ornamental plants* and 2) *grasses, spontaneous vegetation (weeds), and other plants*. The full details of the interview questions can be found in Appendix A. Each interviewee was asked to retrospectively rank their responses on the Likert scale at three different time stages: pre-course, directly post-course, and currently (two years post-course).

After deductive coding was applied to interviewee responses, thematic analysis was employed to identify and categorise patterns in the codes emerging from our participants' responses. Thematic analysis is a method of qualitative data analysis used to identify and analyse different patterns within data (Braun and Clarke, 2006). The thematic analysis uses six key stages for analysis and interpretation, including familiarisation, code formulation, generation of themes, theme review, theme definition and naming, and report formation (Braun and Clarke, 2006). This process was applied to all interviews conducted.

Results

Findings from the Likert scale responses (Figure 2) demonstrated that student interviewees (n=6) mostly did not feel confident in their ability to identify or notice plants before the module, with

students reporting a mean confidence of 3.3 (SD 1.88). However, there was a degree of variation with one student reporting they felt confident in their ability to identify plants (confidence score 7) before the module commenced. Students had a combined mean value for perception of the two vegetation categories 1) *trees, shrubs, and ornamental plants* and 2) *grasses, spontaneous vegetation (weeds), and other plants*) of 5.75 (SD 2.38).

Students reported an increase in their perception and ability to identify and recognise plants immediately after the online course, with the combined median score for both vegetation categories of 8 (SD 1.69) and their general confidence in identifying plants improving to 6.5 (SD 1.6). Encouragingly, students reported that this confidence did not diminish to the present day (two years post-learning), with the median score for confidence in plant identification improving (6.8, SD 1.21) and their ability to notice plants staying the same (8, SD 1.34).

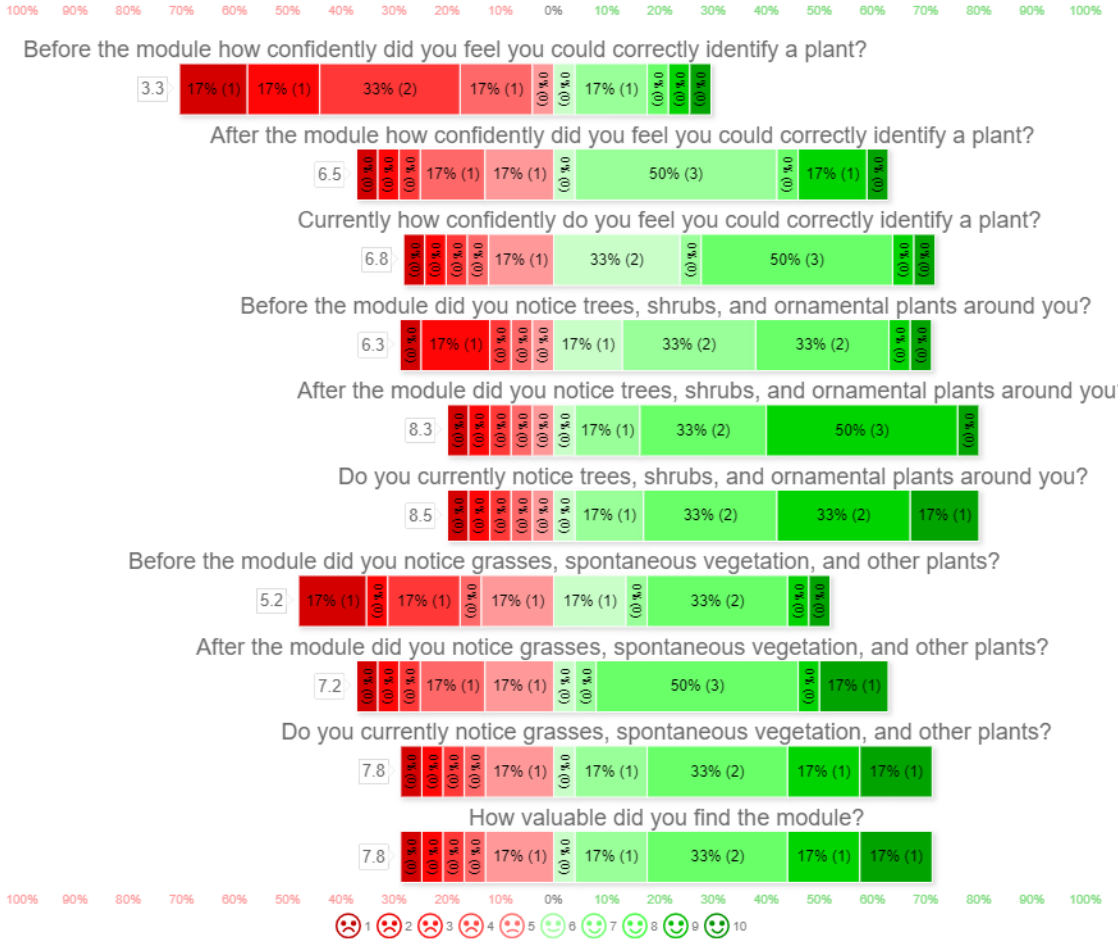

Figure 2: Results of the Likert scale questions regarding students' perceived ability to correctly identify plants and notice local vegetation prior, immediately after, and two years post an online plant identification course during the COVID-19 pandemic. Generally, students regarded their plant identification skills as poor before the series of online workshops but saw strong improvements which were maintained until the time of interviews two years post-teaching.

Students overall found the module to be useful when asked "*How valuable did you find the module?*", with scores ranging from 5-10, with a median of 8. Students reported that whilst they generally struggled to identify plants before the module, there was a large increase in their ability. When students' answers were totalled, their sum doubled from 20 points to 41 currently. Additionally, students also reported an increase in their awareness of the plants, either *trees, shrubs, and ornamental plants* or *grasses, spontaneous vegetation, and other plants*. Both plant groups

noted a marked increase, with 38 for *trees, shrubs, and ornamental plants* before the course, to 49 immediately post-course, and 51 currently. Whilst for *grasses, spontaneous vegetation, and other plants* increased from 31 before the course to 43 immediately post-course, and 47 at time of interview.

The thematic analysis of participant interviews yielded 88 different deductive codes, which were ascribed to 19 broad themes. These included themes focused on students' perceptions of the value of the module such as 'positive wellness value of teaching', content recalled by students from the module such as 'fundamental identification skills' to the challenges encountered with the online format including 'difficulty in engaging online and 'difficulty in observing identification features.' An example of quotes, codes and themes can be found in Table 1. The full list of responses and codes can be found in Appendix B.

Table 1: Example quotes from student interviews, codes, and themes of online plant identification. Some quotes have been edited for clarity and grammar.

Interview Extract	Codes	Theme
"…[group size] perhaps much bigger than that, it would have turned into a bit of a bit of a free for all."	Ability for all to engage	Accessibility of tools used
"Given that it was it had to be drafted of it as an emergency measure. I felt that it was it was adequate for my purposes."	Acknowledgement of limitations of COVID-19	Acknowledgement of limitations of COVID-19
"It certainly increased my enjoyment of being around plants and in natural environments. You certainly made me very aware of just how important plants are."	Developed appreciation of plants	Developed appreciation of plants
"…if you're out with a specific person, you every plant, you come across thinking that oh, this is this, and they can tell you why it's cool. And that gets you're interested in a bit more."	Lacks personal element of plant identification in field	Difficulty in engaging online
"…Like you can't touch or smell them, which I think in some plants that are essential to help you remember." "You can't just then give it to someone and say "Oh, can you have a look at this? I can't find this particular feature on it". "	Missing tactile and sensory element of ID features Difficulty in observing fine ID features	Difficulty in observing identification features
"I thought it was useful, especially just get that first, general idea, because I had never really done any plant ID before other than identifying trees from books."	Value of course	Fundamental identification skills
"Because of the pandemic, it was quite nice to be able to do it in your local area and do the phase one map, because that actually meant that I tried harder to ID stuff."	Local sites more meaning	Independent exploration of local flora
"I imagine if we had it that normally, during the eight hours in the field of plant ID, you really get your eye in."	Shorter sessions than practicals	Limitation of module
"It helped me see different ways of tackling plant identification and learning new techniques, and also sharing knowledge with others."	Peer-to-peer learning support	Peer-to-peer learning
"The Padlet was unbelievably useful. Didn't that get absolutely rinsed? Yeah, I think it was people posting pictures of plants asking for species identification. "I think the online format was valuable, especially as we were all in different parts of the country seeing different plants and vegetation."	Padlet: useful beyond just scheduled session Seeing diversity of species	Sharing of discoveries
"Yeah, I think I probably wouldn't have got this job that I've got now without having done that." "Yeah, I definitely picked up a lot of transferable skills that I've, I've kept since during the module, and it's definitely helping me out, especially now."	Employability and skills development Skills learnt during Plant ID translated to employment	Skills used directly in employment

Many of the students accurately recalled the structure of the module including the specific details of the pre-recorded lectures, such as the families of plants, the set-up of small groups, and GTA led workshops, alongside the different online tools that were utilised such as the online message board and micro-lectures (Figure 3). One student described the workshops as a "*very free and easy open atmosphere, which was really helpful*". Another went as far as to say "*I probably wouldn't have got this job that I've got now without having done that* [the module]". Another student discussed the sense of appreciation they developed for the botanical world during the module, stating that "*day to day life it certainly increased my enjoyment of being around plants and in natural environments. You certainly made me very aware of just how important plants are*". Whilst another stated "*because of the pandemic, it was quite nice to be able to do it in your local area … I tried harder to ID stuff*".

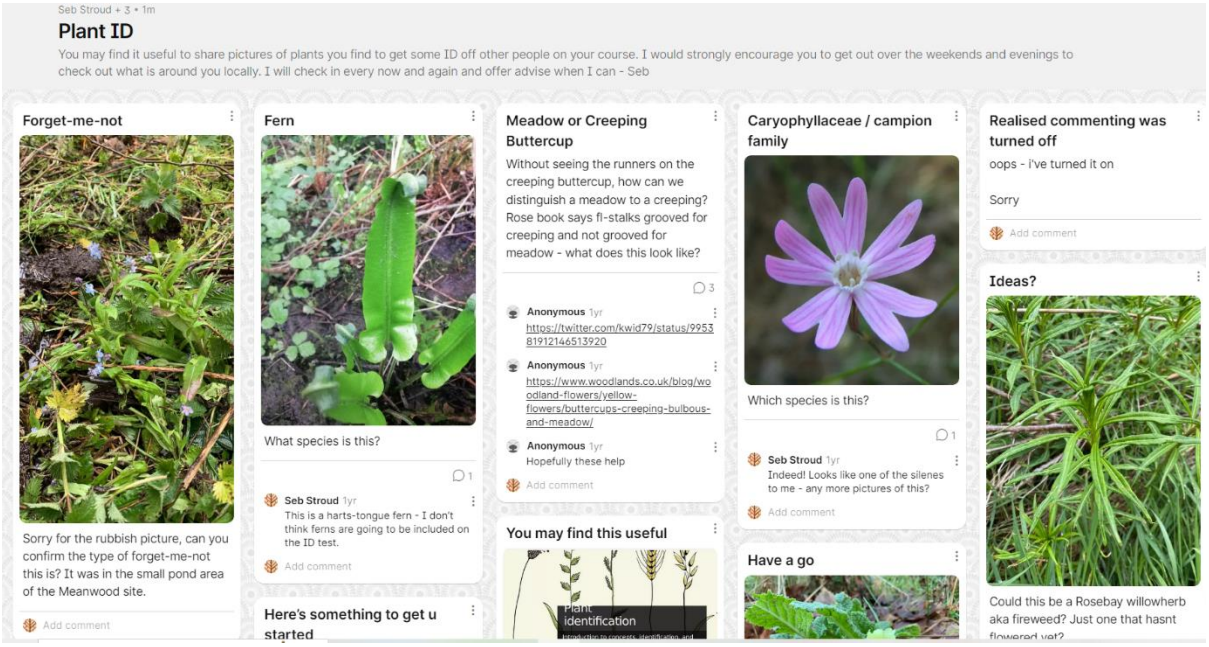

Figure 3: Padlet forum containing various examples of different students' finds and discoveries. Staff monitored the content and identifications of plants on these boards and suggested identification clues and tips, offered potential IDs, and set tasks and challenges.

Discussion

This paper set out to explore the extent to which an online learning approach designed by a GTA was effective in training master's students in plant identification and related skills in plant ecology, and how these approaches might continue to be implemented further in teaching. Out of all the students interviewed, half noted that they use their plant identification skills and understanding of plant ecology regularly in their current roles, with two being employed as botanical specialists within their respective industries. All the students stated that the method of delivery was effective given the restrictions enforced at the time during the COVID-19 pandemic. Students recalled that the ability to watch pre-recorded micro-lectures allowed them to engage in asynchronous learning. Enabling them to tackle the lectures at their own pace and if necessary, go back and rewatch content they did not understand, a finding that has been noted by others (Berlin and Weavera, 2022). However, some students did find difficulty engaging in the online format either due to accessibility issues such as poor internet connection or a more general lack of motivation due to the challenges faced with the lockdown measures (Shevlin et al., 2020).

Some limitations of the methodology were the small number of interviews conducted, self-identification of skill levels, and selection bias (Heckman, 1990). Whilst we had a reasonable response rate to the initial invitation, it is likely the invitation attracted students who felt passionately about plant ecology generally, and it is these students who are likely to have engaged and benefitted the most from the module and continued to develop their skills to the present day. However, all except one participant reported low levels of confidence in their identification ability, and one noted low interest in plants generally (Figure 2). Further interviews with the wider cohort to better understand less engaged student perceptions could be beneficial to this work.

Within higher education, the tools, resources, and technologies at our disposal to teach students have rapidly developed in the last decade. New technologies are being experimented with in teaching settings continuously, from the use of 3D models, virtual and augmented reality experiences, and AI ID tools, to interactive lectures and social media engagement (Cooke et al., 2021). These can be novel, exciting tools which have multiple benefits including accessibility advantages (Morales et al., 2020). There are some additional specific challenges encountered when using an online format, such as observing plant identification features. Many features needed to correctly distinguish different species may be incredibly fine, or even microscopic. The limited tools provided to our students meant that some students might have not been able to correctly observe some of the distinguishing characteristics of the specimens being demonstrated. Some plants may be distinguished by their strong smells, tastes, and textured tissues (Table 1). These are experiences that could not be provided to students through a screen.

However, some students did note the advantage of online learning, such as being able to see a wider diversity of flora that had been gathered by their peers across geographic locations. This is where tools such as the online message board expanded learning capacity. Students from all areas of the UK were able to share the interesting local flora that they found, whilst other students compared similar species that they had noticed in their explorations. This created opportunities for dialogue and discussion around key identification features, facilitating and fuelling peer-to-peer and peer-to-GTA learning and independent inquiry. This was recalled by many of the students during their interviews. Some researchers have noted that educators within the field of ecology observed that many of their students were less involved in online sessions (Bacon and Peacock, 2021). However, I noted that many of the students were diligent and actively engaged in all the online learning activities; students mentioned that the small groups were engaging, allowing active discussion not only with other students but also with myself and the other GTA. Overall, all the students recall fond botanical memories of the module, stating that they did indeed believe that it had enhanced their plant identification skills and their career opportunities in future.

Previous research has indicated the value of nature connection and the development of sustainable attitudes through educational experiences (Krasny and Delia, 2015). Findings on nature connection, education, and exploration of people's local areas are well documented (Frantz and Mayer, 2014). Some students reported that the lack of an experienced botanist to engage them with interesting historical or ecological stories or the physical characteristics of plants in the field left them feeling demotivated within the module. Whilst students felt they could have gained more from their fieldwork, they all reflected positively on its value considering the circumstances of the pandemic. One observation from a student concerned gathering plants from the local area. They noted that they felt a greater connection to this space and therefore felt more motivated to understand the plants that were surrounding them. This motivation that would have been lacking if they had been on the field course not local to them.

Many studies have commented on the general malaise that some students experienced during the pandemic (Wester et al., 2021), due to the stress and uncertainty many people felt during this unprecedented event. Many students are likely to have been facing a suite of new challenges, from

financial struggles to competing for electronic devices with family members, all whilst trying to motivate themselves to study (Chiu, 2022). It is important to note that students remarked on the value of engaging with both nature and each other during the COVID-19 lockdowns. Various studies have quantified the impacts of green space and mental health (Astell-Burt et al., 2022), particularly for urban dwellers during lockdowns (Lin et al., 2023). Several students commented on lockdowns and the value of local exploration, implying that students' wellness likely directly benefitted from the module.

The plant identification module to this day has maintained various elements of the content and format delivered during the COVID-19 pandemic. Additionally, since the pandemic, the University of Leeds has introduced a further field course, the BLGY2265 Urban Ecology and Conservation Field Course. Two key components of this module feature extensive plant identification and plant ecology content, developed by me as a GTA, an opportunity likely not available if not for the success of previous modules. The development and inclusion of this content were in response to the growing concern from academics and myself around plant literacy (Brownlee et al., 2021; Stroud et al., 2022). Whilst most of the teaching of both modules is now delivered in person, they still feature the content and tools created for COVID-19 plant identification module. For example, pre-recorded micro-lectures are still a valuable resource for students to understand plant family characteristics, whilst the use of Padlet encourages peer-to-peer learning and sharing of images of unusual and difficult-to-identify plants. This study also aids in demonstrating the valuable role that GTAs have in developing and delivering taught content throughout the COVID-19 pandemic (McLaughlan, 2021). Within this case study, I was able to plan, design, and deliver a significant proportion of a 20-credit MSc module with relative freedom, a rare opportunity for a GTA. Overall, the opportunity enhanced both my pedagogic practice whilst also enabling an essential skills module for our students to continue with demonstratable success.

The opportunities and lessons learnt from our experiences of distance learning provided us as educators with an opportunity to help increase people's understanding of plant ecology and diversity wherever they may be (Bacon, 2023). One additional direct result of this module was the creation of a free online course on urban green infrastructure and biodiversity for the public. This course was developed in collaboration with the Royal Botanic Garden Edinburgh, and equips students with the skills and knowledge to make better-informed choices about the design and management of green spaces and urban areas for both people and nature (Stroud, 2022).

The COVID-19 pandemic has changed many elements of life from the increase in homeworking, to urban to rural flight, to medical practice. The world of higher education is no different and it has fundamentally changed and accelerated the way we seek to learn and teach. It is expected that much of the UK's higher education environment is not likely to return to conventional lecturing with blended and flipped learning (the viewing of digitized or online lectures as a pre-class activity with active learning experiences such as discussions in class time) featuring more prominently within institutions (Harris et al., 2021; Robson et al., 2022). Since the pandemic, various other studies and case studies have demonstrated similar successes with remote field and lab work; from semi-immersive virtual botanical field trips (Bacon, 2023), at-home laboratory for plant biology (Schnell et al., 2021), online student botanical competitions (BUC, 2023), to virtual internal medicine sub-internships (Holmberg et al., 2021). GTAs have played a significant role in the delivery of much of this content, as they do throughout much of higher education teaching (Muzaka, 2009; Shannon et al., 1998).

Whilst the University of Leeds has returned to mostly in-person teaching, we have seen significant changes in the manner and use of the technology and resource at our disposal. Using the material created and skills developed during the pandemic provided us with a suite of new strategies to help students achieve module learning outcomes, no matter where they are located. More broadly, micro-lectures and independent learning activities can able educators to engage in more engaging

practical or discussion-based activities in person. Models such as flipped learning are becoming a popular alternative to traditional teaching methods, and marry well with blended teaching approaches (Lage et al., 2000; Seery, 2015). The increased learning equity through flexibility of time, study pace, and place is an asset that botanical, and other, educators should aim to capitalise on to expand the currently declining teaching of the discipline post-pandemic.

Conclusion

This paper aimed to assess the effectiveness of our online learning approach for teaching plant identification during the COVID-19 pandemic. I found that across all our participants interviewed, there was consensus that the online delivery was effective at providing plant identification skills given the circumstances. All students improved their ability to identify plants and the increased frequency at which they notice plants in their environment, both immediately and two years after the module concluded. I found that the use of technology enables students to better share their discoveries and enhance their peer-to-peer learning during the pandemic. Collaborative identification efforts gave students a sense of connection during the COVID-19 lockdown. The tools effectively utilised during this time (pre-recorded lectures for independent students, online workshops, AI apps, and online boards) have subsequently been incorporated into the delivery of this module. However, the tactile element to plant identification that students were not able to replicate via an online medium. Students noted during the COVID-19 pandemic some of the most meaningful and valuable learning experiences were those that they were able to share with their peers and educators. Further interviews may help to capture a more comprehensive understanding of student perception and mitigate again the potential self-selection bias of our small sample size.

The increased learning equity and flexibility of blended learning is an asset to botany and field educators. We should aim to capitalise on and expand the declining teaching of the discipline post-pandemic by integrating online materials for blended learning. The days of hiking boots, waterproof trousers and sodden plant keys are far from over for the teaching of field botany, but the next generation of botanists could well have learnt their field skills through a screen.

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References

Abrie, A. L. (2016) The botanical content in the South African curriculum: A barren desert or a thriving forest? *South African Journal of Science,* 112(1-2)**,** pp. 01-07. DOI: http://dx.doi.org/10.17159/sajs.2016/20150127

Astell-Burt, T., Hartig, T., Eckermann, S., Nieuwenhuijsen, M., McMunn, A., Frumkin, H. & Feng, X. (2022) More green, less lonely? A longitudinal cohort study. *International journal of epidemiology,* 51(1)**,** pp. 99-110. DOI: https://doi.org/10.1093/ije/dyab089

Bacon, K. L. (2023) Investigating student experiences of botanical field work using a semi-immersive virtual botanical fieldtrip. *Journal of Biological Education***,** pp. 1-40. DOI: https://doi.org/10.1080/00219266.2023.2192733

Bacon, K. L. & Peacock, J. (2021) Sudden challenges in teaching ecology and aligned disciplines during a global pandemic: Reflections on the rapid move online and perspectives on moving forward. *Ecology and Evolution,* 11(8)**,** pp. 3551-3558. DOI: https://doi.org/10.1002/ece3.7090

Bacon, K. L., Stroud, S. & Peacock, J. (2021) Are you plant aware? *The Niche Magazine.* British Ecological Society.

Berlin, K. & Weavera, K. V. (2022) Teaching strategies students find helpful in online learning courses. *College Teaching,* 70(3)**,** pp. 319-327. DOI: https://doi.org/10.1080/87567555.2021.1940814

Braun, V. & Clarke, V. (2006) Using thematic analysis in psychology. *Qualitative research in psychology,* 3(2)**,** pp. 77-101. DOI: https://doi.org/10.1191/1478088706qp063oa

Brownlee, K., Parsley, K. M. & Sabel, J. L. (2021) An Analysis of plant awareness disparity within introductory Biology textbook images. *Journal of Biological Education***,** pp. 1-10. DOI: https://doi.org/10.1080/00219266.2021.1920301

BUC (2023) *Botanical Univeristy Challenge YouTube channel*. Available at: https://www.youtube.com/@BotanicalUniversityChallenge/streams [Accessed 24/04/2023 2023].

Chiu, T. K. F. (2022) Applying the self-determination theory (SDT) to explain student engagement in online learning during the COVID-19 pandemic. *Journal of Research on Technology in Education,* 54(sup1)**,** pp. S14-S30. DOI: https://doi.org/10.1080/15391523.2021.1891998

Cooke, J., Araya, Y., Bacon, K. L., Bagniewska, J. M., Batty, L. C., Bishop, T. R., Burns, M., Charalambous, M., Daversa, D. R. & Dougherty, L. R. (2021) Teaching and learning in ecology: A horizon scan of emerging challenges and solutions. *Oikos,* 130(1)**,** pp. 15-28. DOI: https://doi.org/10.1111/oik.07847

Drea, S. (2011) The End of the Botany Degree in the UK. *Bioscience education,* 17(1)**,** pp**.** 1-7. DOI: https://doi.org/10.3108/beej.17.2

Frantz, C. M. & Mayer, F. S. (2014) The mportance of connection to nature in assessing environmental education programs. *Studies in Educational Evaluation,* 41**,** 85-89. DOI: https://doi.org/10.1016/j.stueduc.2013.10.001

Godwin, H. (1968) Is Botany Dead? *Nature,* 220(5172)**,** pp. 1155-1156. DOI: https://doi.org/10.1038/2201155c0

Harris, R., Blundell-Birtill, P. & Pownall, M. (2021) " A more personal way to learn during such an isolating time": The value of live lectures in online teaching.'A practice report'. *Student Success,* 12(3)**,** pp. 113-117. DOI: https://doi.org/10.5204/ssj.1781

Heckman, J. J. (1990) Selection bias and self-selection. *Econometrics***,** pp. 201-224. London: Palgrave Macmillan UK

Holmberg, M. H., Dela Cruz, E., Longino, A., Longino, N., Çoruh, B. & Merel, S. E. (2021) Development of a single-institution virtual internal medicine subinternship with near-peer teaching in response to the COVID-19 pandemic. *Academic Medicine,* 96(12)**,** pp. 1706. DOI: https://doi.org/10.1097%2FACM.0000000000004219

Krasny, M. E. & Delia, J. (2015) Natural area stewardship as part of campus sustainability. *Journal of Cleaner Production,* 106**,** pp**.** 87-96. DOI: https://doi.org/10.1016/j.jclepro.2014.04.019

Lage, M. J., Platt, G. J. & Treglia, M. (2000) Inverting the classroom: A gateway to creating an inclusive learning environment. *The journal of economic education,* 31(1)**,** pp. 30-43. DOI: https://doi.org/10.1080/00220480009596759

Lev-Yadun, S., Gopher, A. & Abbo, S. (2000) The cradle of agriculture. *Science,* 288(5471)**,** pp. 1602-1603. DOI: https://doi.org/10.1126/science.288.5471.1602

Lin, B. B., Chang, C.-c., Astell-Burt, T., Feng, X., Gardner, J. & Andersson, E. (2023) Nature experience from yards provide an important space for mental health during Covid-19. *npj Urban Sustainability,* 3(1)**,** pp. 14. DOI: https://doi.org/10.1038/s42949-023-00094-0

McLaughlan, T. (2021) Facilitating factors in cultivating diverse online communities of practice: a case of international teaching assistants during the COVID-19 crisis. *The International Journal of Information and Learning Technology,* 38(2)**,** pp. 177-195. DOI: https://doi.org/10.1108/IJILT-05-2020-0074

Meadows, K. N., Olsen, K. C., Dimitrov, N. & Dawson, D. L. (2015) Evaluating the differential impact of teaching assistant training programs on international graduate student teaching. *Canadian Journal of Higher Education,* 45(3)**,** pp. 34-55. DOI: https://doi.org/10.47678/cjhe.v45i3.187557

Morales, N., Bisbee O'Connell, K., McNulty, S., Berkowitz, A., Bowser, G., Giamellaro, M. & Miriti, M. N. (2020) Promoting inclusion in ecological field experiences: Examining and overcoming barriers to a professional rite of passage. *The Bulletin of the Ecological Society of America,* 101(4)**,** pp. e01742. DOI: https://doi.org/10.1002/bes2.1742

Muzaka, V. (2009) The niche of graduate teaching assistants (GTAs): Perceptions and reflections. *Teaching in Higher Education,* 14(1)**,** pp. 1-12. DOI: https://doi.org/10.1080/13562510802602400

PadLet (2020) *PadLet Image board*. Available at: https://padlet.com/bs17sets3/plant-id-group-project-1513kpf8apxpco8a [2023].

Parsley, K. M. (2020) Plant awareness disparity: A case for renaming plant blindness. *Plants, People, Planet,* 2(6)**,** pp. 598-601. DOI: https://doi.org/10.1002/ppp3.10153

Robson, L., Gardner, B. & Dommett, E. J. (2022) The post-pandemic lecture: views from academic staff across the UK. *Education sciences,* 12(2)**,** pp. 123. DOI: https://doi.org/10.3390/educsci12020123

Ruckelshaus, M. H., Jackson, S. T., Mooney, H. A., Jacobs, K. L., Kassam, K.-A. S., Arroyo, M. T. K., Báldi, A., Bartuska, A. M., Boyd, J. & Joppa, L. N. (2020) The IPBES global assessment: Pathways to action. *Trends in Ecology & Evolution,* 35(5)**,** pp. 407-414. DOI: https://doi.org/10.1016/j.tree.2020.01.009

Saynes-Vásquez, A., Vibrans, H., Vergara-Silva, F. & Caballero, J. (2016) Intracultural differences in local botanical knowledge and knowledge loss among the Mexican Isthmus Zapotecs. *PloS one,* 11(3)**,** pp. e0151693. DOI: https://doi.org/10.1371/journal.pone.0151693

Schnell, L. J., Simpson, G. L., Suchan, D. M., Quere, W., Weger, H. G. & Davis, M. C. (2021) An at-home laboratory in plant biology designed to engage students in the process of science. *Ecology and Evolution,* 11(24)**,** pp. 17572-80. DOI: https://doi.org/10.1002/ece3.8441

Seery, M. K. (2015) Flipped learning in higher education chemistry: emerging trends and potential directions. *Chemistry Education Research and Practice,* 16(4)**,** pp. 758-768. Available at: https://doi.org/10.1039/C5RP00136F

Shannon, D. M., Twale, D. J. & Moore, M. S. (1998) TA teaching effectiveness: The impact of training and teaching experience. *The Journal of Higher Education,* 69(4)**,** pp. 440-466. DOI: https://doi.org/10.1080/00221546.1998.11775144

Shevlin, M., McBride, O., Murphy, J., Miller, J. G., Hartman, T. K., Levita, L., Mason, L., Martinez, A. P., McKay, R. & Stocks, T. V. A. (2020) Anxiety, depression, traumatic stress and COVID-19-related anxiety in the UK general population during the COVID-19 pandemic. *BJPsych open,* pp. 6(6). DOI: https://doi.org/10.1192/bjo.2020.109

Steffen, W., Broadgate, W., Deutsch, L., Gaffney, O. & Ludwig, C. (2015) The trajectory of the Anthropocene: the great acceleration. *The Anthropocene Review,* 2(1)**,** pp. 81-98. DOI: https://doi.org/10.1177/2053019614564785

Stroud, S. (2022) *Botany for the Built Environment*. RBGE PropaGate: Royal Botanic Gardens Edinburgh. Available at: https://propagatelearning.rbge.ac.uk/enrol/index.php?id=288 [Accessed May 2023].

Stroud, S., Fennell, M., Mitchley, J., Lydon, S., Peacock, J. & Bacon, K. L. (2022) The botanical education extinction and the fall of plant awareness. *Ecology and evolution,* 12(7)**,** pp. e9019. DOI: https://doi.org/10.1002/ece3.9019

Wandersee, J. H. & Schussler, E. E. (1999) Preventing plant blindness. *The American Biology Teacher,* 61(2)**,** pp. 82-86. DOI: https://doi.org/10.2307/4450624

Wester, E. R., Walsh, L. L., Arango-Caro, S. & Callis-Duehl, K. L. (2021) Student engagement declines in STEM undergraduates during COVID-19–driven remote learning. *Journal of microbiology & biology education,* 22(1)**,** pp. ev22i1-2385. DOI: https://doi.org/10.1128/jmbe.v22i1.2385

Appendices

Appendix A: Questions for semi-structured interviews.

Likert scale questions:

How confidently did you feel you could correctly identify a plant?

Would not be able to identify anything 1-10 Would be able to identify everything

Did you notice trees, shrubs, and ornamental plants around you?

Never notice 1-10 – notice nearly everything

Did you notice grasses, spontaneous vegetation (weeds), and other plants?

Never notice 1-10 – notice nearly everything

How valuable did you find the module?

I did not learn any valuable skills 1 – 10 I use the skills I learnt daily

Open questions for the interviews included the following:

Can you please briefly describe your recollection of how you were taught plant identification?

What did you find valuable about the delivery method?

What did you find challenging about the delivery method?

Do you think the method of delivery was effective?

Has this course enhanced your botanical identification skills and what has been the impact of this?

Appendix B: Student responses to interview questions with respective codes and themes.

Interview extract	Codes	Theme
[group size] perhaps much bigger than that, it would have turned into a bit of a bit of a free for all.	Ability for all to engage	Accessibility of tools used
[prerecorded lecture] so you can go through it in your own time	Asynchronous learning	
I liked the small groups with the teams calls	Small group: ability for all to engage	
That's, that would have been great, obviously wasn't possible at the time. Basically, I don't think all of plant ID needs to be done in person	Acknowledgement of limitations of covid	Acknowledgement of limitations of covid
Given that it was it had to be drafted of it as an emergency measure. I felt that it was it was adequate for my purposes.	Acknowledgement of limitations of covid	
It certainly increase my enjoyment of being around plants and in natural environments. You certainly made me very aware of just how important plants are.	Developed appreciation of plants	Developed appreciation of plants
Yeah, I definitely think it improved that, definitely think that it can get the ball rolling with my interest	Developed appreciation of plants	
I wasn't very, like self driven and motivated to get better at it.	Difficulty in engaging online	Difficulty in engaging online
if you're out with a specific person, you every plant, you come across thinking that oh, this is this, and they can tell you why it's cool. And that gets you're interested in a bit more.	Lacks personal element of plant identification in field	
the pandemic might have had an effect on my motivation.	Impacts of pandemic on mental health: negative	
You can only really look at specimens are shown, you know, you can't be able to remember particular species by any other sense	Difficulty in observing fine ID features	Difficulty in observing ID features
Like you can't touch or smell them, which I think in some, some plants that are essential to help you remember.	Missing tactile and sensory element of ID features	
You weren't in like a lab with other people you couldn't physically show apart from up to a camera	Difficulty in observing fine ID features	
You can't just then give it to someone and say "Oh, can you have a look at this? I can't find this particular feature on it".	Difficulty in observing fine ID features	
It was hard to get across on online formats, like taking like a blurry photo of the part of a plant.	Difficulty in observing fine ID features	
I think, how to identify families	Identification of families	Fundamental identification skills
And then in the specific breakouts, we kind of had we focused on like one or two families per like, seminar type thing.	Identification of families	
So the online stuff was, like, general information about working things out families	Recall of families	
My recollection is sort of going out in the mornings, collecting other plants that I thought were in certain families.	Recall on families	
I thought it was useful, especially just to sort of get that first like, general idea, because I had never really done any plant ID before other than, like, identifying trees, like from books	Value of course	
So I thought that was really useful just to have that sort of broad overview of obvious families.	Recall of families	
So it was like, you know, go out into your local area and find a pea or something	Fieldwork component	Independent exploration of local flora
because of the pandemic, it was quite nice to be able to do it in your local area and do the phase one map, because that actually meant that I tried harder to ID stuff,	Local sites more meaning	

I imagine if we had it that normally, during the eight hours in the field of plant ID, you really get your eye in	Shorter sessions that practicals	Limitation of module
And I think maybe only doing the couple of sessions that we did. Maybe it didn't go in that much	Limitation of time for practicals	
[Due to poor internet] So the delivery of the teaching was also there's not always as smooth as it would be in person	Internet accessibility issues	
helped me see different different ways of tackling plant identification and learning new techniques, and also sharing knowledge with others	Peer to peer learning	Peer to peer learning
And then we'd come back and talk to each other about how we did it [identified a plant]	Peer to peer learning	
you could sort of bounce off each other and learn off each other.	Peer to peer learning	
[small group size] I found that quite useful, because it meant that there was only four or five of us in the conversation, which was good	Small group: valuable	
Value of padlet: novel new tool	Padlet: useful beyond just scheduled session	Sharing of discoveries
So if you brought a different species, you've looked at five separate species, whereas I feel like if it was just in a big room, or whatever, I think I'd probably just be focusing on myself	Peer to peer learning	
I feel like if it was just in a big room, or whatever, I think I'd probably just be focusing on myself.	Greater diversity of specimens to look at - different locations	
I think the online format was valuable, because especially as we were all in different parts of the country seeing is obviously different plants and vegetation stuff around the country seeing different examples	Seeing diversity of species	
Yeah, I think I probably wouldn't have got this job that I've got now without having done that.	Employability and skills development	Skills used directly in empolyment
And now, I still use that ID in my current job as well.	Skills learnt during Plant ID translated to employment	
Yeah, of course, like, just the family stuff, like the font like the fact that I can identify like a cabbage family or a rose family and stuff. I think that I think that quite helped me out a lot.	Skills learnt during Plant ID translated to employment	
Yeah, I definitely picked up a lot of transferable skills that I've, I've kept since during the module, and it's definitely helping me out, especially now	Skills learnt during Plant ID translated to employment	
it's although I don't really use the keys and stuff, I usually use more like those apps where you can take photos	Use of identification apps	
I use that a lot, because with my job, it's quick ID. But then I also when I do use those apps, I know to double check the ID. So I look on Wikipedia wherever it is and read why the description of the plants and see if it does have you know,	Skills learnt during Plant ID translated to employment	
I think it would have been, you know, ideally, we would have had maybe like to do it maybe halfway through what was the end? Kind	Suggestions for group field	Suggestions for improvements
ideally, we would have had maybe like to do it maybe halfway through what was the end?	Lack element of face-to-face expert interaction	
So it's maybe that access to you can't really prove that online. But I feel like if we didn't have more time	Timescale of course challenging	
I guess the normal trip trips out and stuff were really honed in those skills a lot more. So I feel like maybe I missed out on honing those.	Lack of trips for module	
Yeah, knowing what every plant is.		
Going out in the morning, trying to find plants from certain families, especially given like the location here in Portsmouth. So In the city.	Unequal access to plants	Unequal access to materials
So it's maybe that access to you can't really prove that online		
The Padlet was unbelievably useful. Didn't that get absolutely rinsed? Yeah, I think it was people posting pictures of plants asking for species identification. Other people could get involved help point out those characteristics that were important for identification for that particular plan, or group of plants	Specific purpose of Padlet	Use of novel teaching tools

There was a good critical mass behind that. And that really helped to get it going. And it was just like, yeah, open atmosphere. Okay, great.	Use of padlet - helpful	
The might be some diagrams, I remember that the the format was we all had specific specimens highlighting particular characteristics, and then we put them through them one by one and see how they do general scheme of things. In terms of other tools. I can just remember things on the screen. That's fine.	Uncertainty in recalling structure	Vague recollection of module
The might be some diagrams, I remember that the the format was we all had specific specimens highlighting particular characteristics, and then we put them through them one by one and see how they do general scheme of things. In terms of other tools. I can just remember things on the screen. That's fine.	Did not recall specifics	