Designing a bespoke App to address *Botanical literacy* in the undergraduate science curriculum and beyond

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At the University of Sydney we are offering a revised botany program within the biology curriculum that has reduced the time dedicated to the study of botany. Given the overall decrease in basic botanical science courses taught at university level and the need to improve the botanical literacy of our future biology graduates and high school teachers, how can we better connect students to the practice of botany and so improve botanical literacy? One solution is to draw on 'App', 'mobile' technologies to map the campus flora and our aim was to develop a dynamic and interactive geo-locating botany iPhone app, which aligns to the Botany curriculum and offers a unique opportunity for the broader community to view the campus through a botanical lens.

Keywords: botany, botanical literacy, undergraduate science, mobile technology

Introduction

Much has been written about how to best use new and emerging technology-based innovations in teaching and learning with the most successful being those that enrich student learning experiences. In Biology, "Web 1.0" information and communication technological (ICT) solutions have provided students with access to collections of learning objects that include virtual dissections, virtual microscope slides, virtual lab benches and virtual experiments. Improvements in mapping (geolocation resolution) and mobile device technology offer the capacity to better connect students with the living botanical world as opposed to virtual solutions. For botany educators there is enormous appeal in exploiting 'app' and 'mobile' technologies to connect students with the plants in their surroundings with the view to increase botanical literacy.

Botanical literacy in the undergraduate curriculum

For almost 100 years it has been acknowledged that the participation in the study of plants at university level has been in decline (Nichols, 1919; Hershey, 1993; Uno, 1994; Drea, 2011). The reasons for this decline are unclear. Many degree programs have had subjects such as botany and zoology merged to create a general biology program and, without a clear botanical distinction, much of the teaching has focused on animal examples (Hershey, 1996). New and emerging biology disciplines (genomics, proteomics, molecular biology) have impacted on the amount of botany being taught and when given a choice of using plants or animals to illustrate a concept animal examples again dominate (Hershey, 1996). The changing value that an increasingly urbanised society is placing on plants could also be partly to blame for falling participation in a botanical education. The UK, with its rich history of plant science, discontinued its last pure botanical degree in 2010 due to diminishing numbers of students selecting this particular degree (Drea, 2011); Drea found that words such as "plant" or "agriculture" could have an adverse effect on enrolment rates. Similarly, enrolment rates in botany and plant science majors have declined in the USA (Uno, 2009). A critical issue to be addressed is, how can student engagement in botany be improved? Strategies that encourage a (re)connection with plants and nature are to be viewed as a beneficial way to increase participation in botanical learning and thereby providing opportunities to improve *botanical literacy* (Hemingway et al., 2011).

Critical components of our society such as agriculture, biofuels, nutrition, water cycles and environmental issues rely on a sound understanding of botanical principles for informed debate and decision-making. In short, society benefits from a scientifically aware population with an appropriate level of *botanical literacy*. Wandersee and Schussler (2009) describe the inability to see or notice the plants in one's environment as *plant blindness*. *Plant blindness* is connected to, and compounded by, the disturbing trends in botanical education (described above) and in the community more broadly. Research by ethnobotanists tells us that, historically, plants from within a local area were utilised by a person for a range of purposes including food, medicine, tools, watercraft, housing, clothing, hunting equipment and rituals (Clark, 2012). Cultures that still practice traditional ways of living continue to draw upon local plant resources for a variety of needs (Galeano, 2000; Couly & Sist, 2013). This direct reliance fosters a deep knowledge of the locations and cycles of plants and gives cues on available food sources, seasons, weather and hunting opportunities. Many people from traditional cultures view themselves, plants and the natural world as interconnected, and in some sense related, each part affecting each other part (Salmón, 2000). This kincentric human-nature relationship view can lead to a greater appreciation, respect and understanding of plants. With the development of an agricultural way of life, local plants continued to be an integral part of life upon which people had a direct reliance. Even today, studies have shown that people who garden have a stronger connection and concern for plants and the environment than those that do not (Lowe, 2007). This highlights the importance of initiatives such as this that increase the visibility of plants.

Experiences lead to engagement and understanding and this is well illustrated in a unique school education program in Switzerland for children aged 8-16 years old (Lindemann-Matthies, 2005). The basic premise of the program was to engage students with their local environment and the highlight of this program involved children framing a plant that they particularly valued with a picture frame and talking to passers by, other students, parents and even the media as to why they had selected that particular organism. This program encouraged children to increase awareness of plant as key components in the built environment and natural world. Program surveys concluded that students gained a huge appreciation and awareness for the organisms found in their local environment.

Technology-enhanced learning in Botany

Technology used in conjunction with other interactive and experience-driven resources can help (re)connect students with learning about plants in ways that generate interest and positive engagement (Hemingway et al., 2011), and, as a result, *plant blindness* is lessened. ICT learning resources have benefits including being easily customisable and editable and able to be tailored to a specific audience, such as those learning the practice of botany. It can be daunting for a student new to botany to use a resource that is tailored to the professional botanist. The following are examples of where ICT is being used to improve participation and learning in botany. Online developments include web pages such as online identificatory keys and learning object repositories. Notably the evaluation of the online identificatory key from the University of Aveiro saw an improvement in the identification of vascular plants from 54.4%, to 80.2% when students used an online key. The most recent initiatives exploit advances in mobile device technology and improvements in mapping resolution for the development of trails, and social networking practices to broaden data collection collaborations (Table 1).

Aim

The objective of this project was to create a technology-enhanced guide, an App, to allow users to interact with plants around the University of Sydney campus to foster a better appreciation of the botanical richness in the campus environment. Like many campuses, The University of Sydney campus has a wealth of interesting plants, which represent forty plant families and many of which are used in educational activities. Hence the development of an interactive web based application aiming to get cohorts of science and education students interacting with plants around their campus. To address *plant blindness* in biology and to connect undergraduate science students entails creating innovative ways to (re)invigorate interest in botany.

Design narrative

In order to appreciate the potential that this project encapsulates it is important to understand the goals it sought and to follow its current and future development. The initial direction of the project was to capture and catalogue a range of plants from around the University of Sydney campus and to present it in a way that was engaging and useful to students that were just beginning their journey to a higher biological understanding. This project originated as a second year student project in 2013, which was extended to a Summer Scholarship in 2014 and was developed in two broad stages with the second stage focused on extending the content and improved mapping functionality. Arguably, the more important aspect was identifying collaborators to extend the audience, and so the appeal, of the App to the broader university community.

Proof of concept

Stage 1 was a 'proof of concept' and stemmed from the perceived usefulness of WebApp in teaching and learning botany (particularly in the second year undergraduate Botany course) using the plants on campus. This stage focused on content, rudimentary mapping functionality and a specific target audience; all of these informed the structure of the information database at the backend and the design of the user interface at the front end of the WebApp. The user interface is minimalistic to highlight the visual elements: graphics, photographs and concise textual descriptions. The navigation and functionality were kept as simple and intuitive as possible while keeping within the remit of coding for all web-based platforms. The information displayed is not as extensive as would be expected of a resource used by professional botanists (Figure 1) as it is tailored to the needs of undergraduate biology students for simplicity and usability.

Table 1: Technology-enhanced learning in Botany: uses and functionalities

Use and online functionality	Examples
Online identificatory keys: digital format improves searchability	a) University of Aveiro (Silva et al., 2010) http://www.biorede.pt/index2.htm b) The University of Sydney: eFlora: Vascular Plants of the Sydney Region http://eflora.library.usyd.edu.au/ (Henwood et al., 2006) c) La Selva Biological Station, Costa Rica, wiki for students visiting the rainforest to identify 65 of the most common families based on identification of some basic morphology (Shumway et al., 2010). http://wikis.wheatonma.edu/rainforest/index.php
Object repositories: metatags improve searchability and sharability	a) The University of Sydney: eBot Plant Sciences Collection (Quinnell et al., 2009) b) http://ebot.library.usyd.edu.au/Royal Botanic Gardens Kew: KewImages http://images.kew.org/
Themed trials: these bring botanical information to the field and broaden the interest of a defined collection of plants	a) Cambridge University Botanic Gardens "chemical trail". Users with a web-enabled device can access, via a QR code, information on phytochemicals derived from plants in the university's collection (Battle et al., 2012). This tool provides an interactive experience linking common phytochemicals to plants within the Botanic Gardens, which are part of the campus grounds. http://www.botanic.cam.ac.uk/Botanic/Trail.aspx?p=27&ix=11 a) UNSW 'green trail' is an app, which includes 25 plants themed to promote the practice of environmental sustainability. Information includes descriptive text/sound files for each plant together with a location map. https://itunes.apple.com/au/app/unsw-green-trail/
Collaborative data gathering: broadens the base of users contributing scientific data	ClimateWatch (2012) App allows sightings of animals, plants, protists, fungi to be recorded with date stamped, geolocated photographs. The emphasis here is using the community at large to assist in gathering data sets for biodiversity. http://www.climatewatch.org.au/mobile

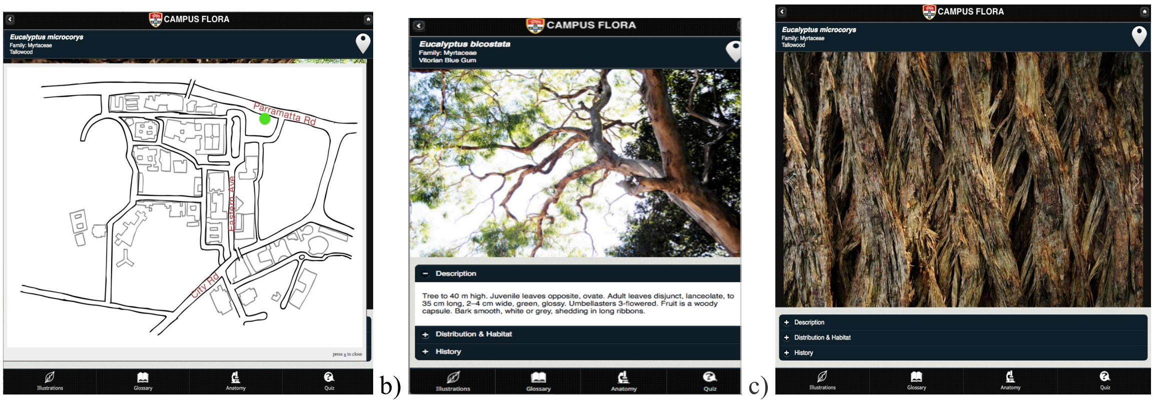
a)


Figure 1. Screenshots of initial development of Botany WebApp has a) a static map showing tree location, b) descriptive text and c) an image gallery to highlight botanically important features of the plant.

The plants (n ~ 50) selected for inclusion in the WebApp were those that were used in the undergraduate Botany curriculum. Botanically important features of these plants were photographed and Global Positioning System (GPS) coordinates recorded and these data stored in a simple database together with phylogenetic information and descriptive information. In its initial form, the WebApp offered the locations of the plants as static geographic maps and offered two ways to interact with botanical content. One focused on plant diversity and the other on plant evolution - plant diversity and plant evolution are key concepts in the undergraduate Botany curriculum. For plant diversity a geographic map and image-based interface were offered to the user so they could select one of three locations on campus and then explore the plant diversity in that region. For plant evolution an interactive phylogenetic map was used to access the content database and enabled users to take a tour of non-flowering plant around the university.

The pilot demonstrated the capability of creating a WebApp that could draw from a single dataset in a variety of ways to communicate botanical information aligned to themes. For us it was important in the context of utilising a single resource to engage different groups of people. Further, if a tool was required to incorporate more advanced botanical knowledge that data could potentially be drawn from the same database by accessing different fields. WebApp URL: http://student.sydneybiology.org/campusflora/

Technical specifications
For the pilot we were working to the following technical specifications:

- Architecture: HTML5 and CSS3
- Target devices: Mac, PC, mobile devices
- Main features: Plant mapping, plant information, slideshows, glossary of terms

iPhone App development

The second stage of development was to develop an iPhone App, called CampusFlora, to allow for more sophisticated mapping functionality and to include user location (Figure 2). At this stage we are integrating information from the campus tree database, an ArborPlan database, however, ArborPlan uses Universal Transverse Mercator location coordinates which need to be GPS coordinates suitable for MapKit framework. We have incorporated information from ArborPlan to create an extensive 'mother' database and in doing so we will take the number of individual plants in the Campus Flora from n ~ 50 to over 1000. Our mother dataset can be used to generate the XML file suitable for use in the iPhone App and be expanded and updated for incorporation into a revised WebApp.

Additional information has been added to support the themed trails such as 'Non-flowering Plants' (as described above), 'Native Plants', and 'The 'eucalypts''. There is the potential to develop additional trails e.g. medicinal plants, chemical plant trail, and a trail aligned with the University's Aboriginal and Torres Strait Islander integrated strategy: Wingara Murra – Bunga Barrabugu) with indigenous partners. In essence the CampusFlora App presents a shift from a model where scientific knowledge is collected and disseminated by a narrow group of people to one that is inclusive and more broadly accessible that offers phylogenetic, morphologic, locational and visual data configured in aesthetically interesting ways.

iPhone App technical specifications
This development uses Swift so as to be compatible with the upcoming new iOS 8. Details of the technical specifications are:

- Development platform: Xcode 6
- Target devices: iPhone 4 and above
- Main features: Plant mapping, navigation, plant information, slideshows
- Frameworks: Foundation, CoreGraphics, UIKit, Mapkit

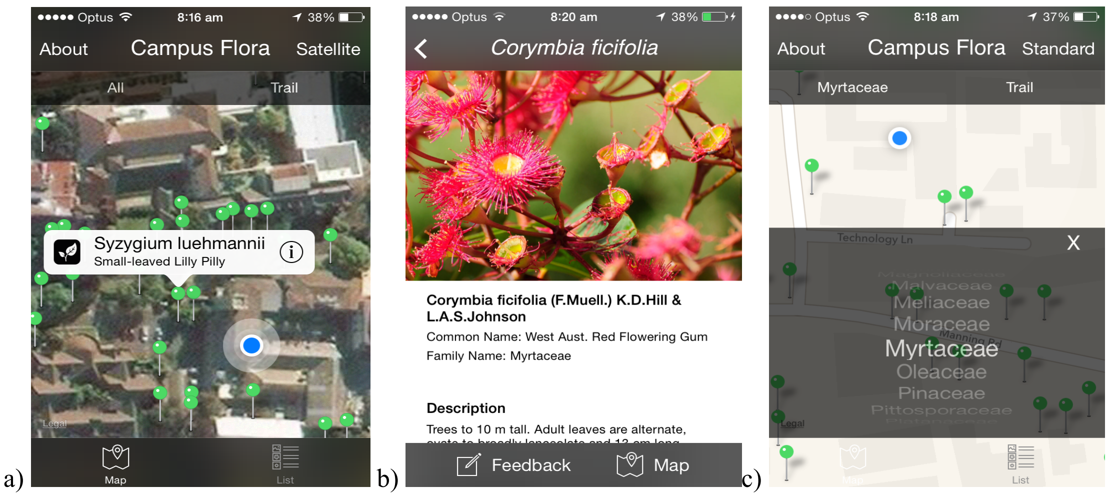


Figure 2. Screenshots of Botanical iPhone app. a) Interactive map showing locations of plants (green pins) in relation to user (blue pin), selecting a plant location pin brings up name of the plant and b) clicking the pin takes the user to descriptive text and image gallery for this plant to highlight botanically important features, c) plant families can be selected, a feature which aligns with the botany curriculum.

Conclusions

As of September 2014, our University Marketing is evaluating CampusFlora and Communication team prior to being submitted the iPhone App to the AppStore. With respect to evaluating the App, we are doing this in an inclusive and collaborative way by building in feedback functionality so that we can assess usefulness and usability once the App is launched and a 'like' function so users can tag their favourite plants. We are yet to undertake a formal evaluation but we can report that the second year Botany students, who were given access to the original WebApp and who were invited to beta-test the App, were extremely enthusiastic about this initiative and our colleague educators were able to appreciate the enormous potential of this development in the Botany curriculum.

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