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An Interactive Multimedia Dichotomous Key for Teaching Plant Identification

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Teaching plant identification includes demonstrating how to use dichotomous keys; this requires knowledge of numerous botanical terms and can be challenging, confusing and frustrating for students. Here, we developed a multimedia tool to help students (1) learn botanical terms, (2) practice, train and test their knowledge of plant identification and (3) self-evaluate their level of learning. We generated an interactive dichotomous key for about 280 species of vascular plants from Belgium and the surrounding territories to help teach botany and plant identification to university students. To make the identification keys user friendly and appealing, we constructed databases with several thousand interactive links, including a descriptive and illustrated glossary (explaining more than 800 botanical terms with original drawings). This interactive multimedia dichotomous key includes family, genus and species descriptions, basic plant evolution and life cycles, as well as quizzes and tests. The description sheets present plant morphology, vegetative and reproductive characteristics, distribution area, ecology and classification (following Angiosperm Phylogeny group APGIII). The website is available at www.biologievegetale.be. Here, we used plant identification as a model to apply the principles of dichotomous keys; the same approach could be applied to all disciplines within systematics.

Keywords: *Teaching/learning strategies; Higher education; Systematics; Interactive dichotomous keys*

Introduction

Plant identification remains essential for conservation, detection of promising pharmaceutical compounds, weed management, horticulture, forestry and agronomy. For example, accurate classification of individuals into species is crucial for conservation of biodiversity as rare and threatened species can be conserved only if they are recognised

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as such. Preservation of species and ecosystems is an urgent issue, and biodiversity remains a fundamental concept in teaching biology (Convention of Biological Diversity 1996). Still, there is a worldwide lack of people who can accurately identify species (Kirchoff et al. 2014). Currently, many biology and agronomy programmes lack a focus on the organism/species level since these programmes concentrate on molecular biology or ecology and ecosystems (Silva et al. 2011). The importance of the species level, fundamental for understanding higher levels of categorisation, has been neglected since the second half of the twentieth century (Flannery 2001), which is also reflected in the teaching of systematics.

There is evidence that students prefer learning about animals rather than plants, which may be related to the short time dedicated to botany in both primary and high school (Schussler and Olzak 2008). 'Plant blindness', meaning the inability to see plants as part of the living environment, occurs in students and in society in general (Wandersee and Schussler 2001). However, plants are not a static 'green screen'. They have developed diverse and amazing interactions among individuals of the same species, with other plant species, and with species from other kingdoms (fungi, bacteria and animals). Plants play vital and active roles in those diverse interactions, which include symbiosis, parasitism and allelopathy.

Plant identification is usually taught at university and in horticultural schools, either as part of a course in plant systematics or in field botany (Kirchoff et al. 2014). The teaching of plant identification includes showing students how to use dichotomous keys. Such dichotomous keys represent one way to teach systematics, with the objective of being able to identify unknown taxa. The user makes a series of determinations about the characteristics of the unknown species; if the determinations are correct, the key gives the student the identity of the organism.

In using keys, students must be observant and learn the technical terms upon which the keys depend (Kirchoff et al. 2014). Thus, the use of these keys requires knowledge of numerous botanical terms and some field experience, which students often lack (Silva et al. 2011). In our university, identification of vascular plants is one of the subjects in the 'Plant science' discipline for undergraduate students in biology, bioscience engineering, agronomy and pharmacy. The identification of vascular plants is taught in a way that attempts to provide an overview of the morphological features of the more relevant families of vascular plants. This should raise awareness about why and how plants live and interact with other organisms, their role in ecology and evolutionary processes and their importance in the maintenance of ecosystem services. For these courses, plant identification focuses on Belgian plant species of agronomic, ecological or pharmacological importance. Moreover, these courses describe all Belgian wild and planted tree species, including gymnosperms and angiosperms, as well as native and exotic plants. The description sheets are also used for teaching courses at the Master's degree level, such as Dendrology and Plant Vegetation Analysis. Several hundred students enrol in these courses each year.

One way to acquire expertise in species identification involves repeated exposure and practice. However, class time is insufficient to learn reliable, experienced-based identification. To teach biodiversity, many practitioners and teachers prefer settings suitable for outdoor ecological education (Randler 2008; Stagg and Donkin 2013). In the field,

students learn more than the name of the species; they are also introduced to the ecology (soil, type of biotope, etc.), the distribution and many recognisable traits of the plant, including its size, odour and texture. However, field botany remains expensive and time consuming. Furthermore, outdoor activities should be properly framed by a preceding educational unit in the classroom (Kirchoff et al. 2014; Randler 2008). Thus, multimedia learning tools focused on species identification, available both in classrooms and in the field, are urgently needed (Campbell et al. 2011).

Here, we describe the development of a multimedia tool designed for students to: (1) learn botanical terms, (2) practice and test their knowledge of plant identification and (3) self-evaluate their learning level. In this work, we used plant identification as model for applying principles of dichotomous keys. Identification of other species (e.g. insects, fungi, snakes or birds) requires similar learning, based mainly on dichotomous keys and specific terms.

Methods

Development of Interactive Dichotomous Keys and Multimedia Tools

Interactive dichotomous keys were elaborated based on the flora used during practical courses on fresh plants (Bastin et al. 2007; Lambinon and Verloove 2012; Rameau, Mansion, and Dumé 1989) and on glossaries of botanical terms (Boullard 1999; Lambinon and Verloove 2012). Dichotomous keys were transcribed for nearly all of the 111 plant families present in Belgium. Two databases were constructed with several thousand interactive links: a descriptive glossary of more than 800 botanical terms and an illustrated glossary containing more than 120 original drawings.

A set of photos at each step of the dichotomous key helps the user choose between the two options. The photos include a general view of the plant, as well as details of the leaves, corolla, sexual organs, fruits and seeds (Figure 1). Enlarged versions of the photos are available to examine in detail. The pictures were taken with a Canon EOS50D camera (18–55 mm lens) in the field or a Nikon Coolpix 4500 camera mounted on a binocular microscope in the laboratory. Photos were retouched with Digital Photo Professional software.

Since the academic year 2014–15, the interactive dichotomous keys have been available at the 'biologie végétale' website (www.biologievegetale.be or http://www.afd-ld.org/fdp_bio/index.php), in the section about identification exercises 'exercices de détermination' (http://www.afd-ld.org/fdp_bio/index.php?rub=exercices-de-determination).

The interactive tool is user friendly for teachers, high school and university students, as well as for amateur botanists. It is available both in classrooms and in the field (the site can be used on smartphones and tablets). For example, students are invited to use it in the field for vegetation surveys (e.g. vegetation analysis during the master's degree).

For ease of use, the information in the website is divided into four independent sections:

(1) Main plant phyla: This section describes the main plant branches (Bryophyta, Pteridophyta, Gymnosperms and Angiosperms) as well as the history of plant classification and basics of taxonomy. The APGIII classification (Angiosperm phylogeny
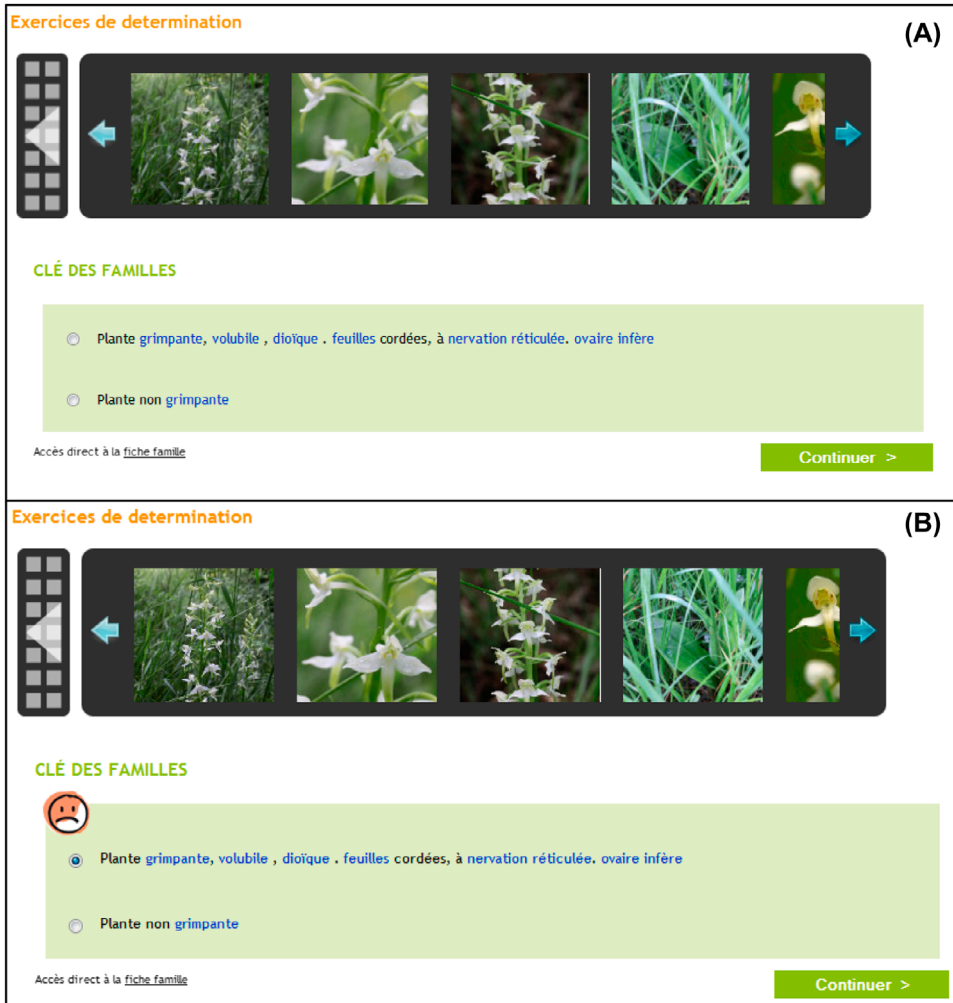
Figure 1.   (A) Online page of the interactive dichotomous key presenting both the pictures of the unknown plant species and the binary choice and (B) mistakes reported with a grimace face. Words highlighted in blue refer to the illustrated glossary

group, http://www.mobot.org/MOBOT/research/APweb/) is briefly explained. These chapters are devoted to basic knowledge of plant reproductive systems, life cycles and evolution.

(2) Identification practice: Following the interactive dichotomous key, students train themselves to identify plant species and learn botanical terms. By December 2014, 70 species illustrated with more than 700 photographs were included on the website: http://www.afd-ld.org/fdp_bio/index.php?rub=exercices-de-determination, Figure 1). Botanical terms included in the glossary (highlighted in blue) are defined and, if needed, illustrated in the glossary (available at http://www.afd-ld.org/fdp_bio/index. php?rub=glossaire). At each step of the key, a correct answer allows the user to go to the next step and an incorrect one is highlighted with a grimace face (Figure 1(B).

(3) Web flora: Users can access a family, genus or species via different search links, for example for the family, or for the Latin or the French name, following the dichotomous key (http://www.afd-ld.org/fdp_bio/index.php?rub=flore-en-ligne). Information sheets present vegetative and reproductive morphological traits, distribution area, biotopes, ecology (soil humidity and mineral status), successional position and pharmaceutical properties (Figure 2). This additional information can help motivate students and provides links to conservation issues, agronomy and other practical uses of plants. As not all Belgian species are available in the database yet, students (and other interested people) are invited to write new information sheets for species or genera through an interactive form (http://www.afd-ld.org/fdp_bio/admin/login.php).

Feedback from users is also important and can be provided by following a link (https://tools.uclouvain.be/limesurvey191/index.php?sid=79,558&lang=fr).

(4) Quizzes and questions: These allow students to evaluate their level of knowledge (http://www.afd-ld.org/fdp_bio/index.php?rub=evaluez-vous). The questions include links between families and species, botanical terms for reproductive and vegetative structures (Figure 3), as well as an ecosystem approach with links between biotopes, indicator species and environmental variables such as soil type.
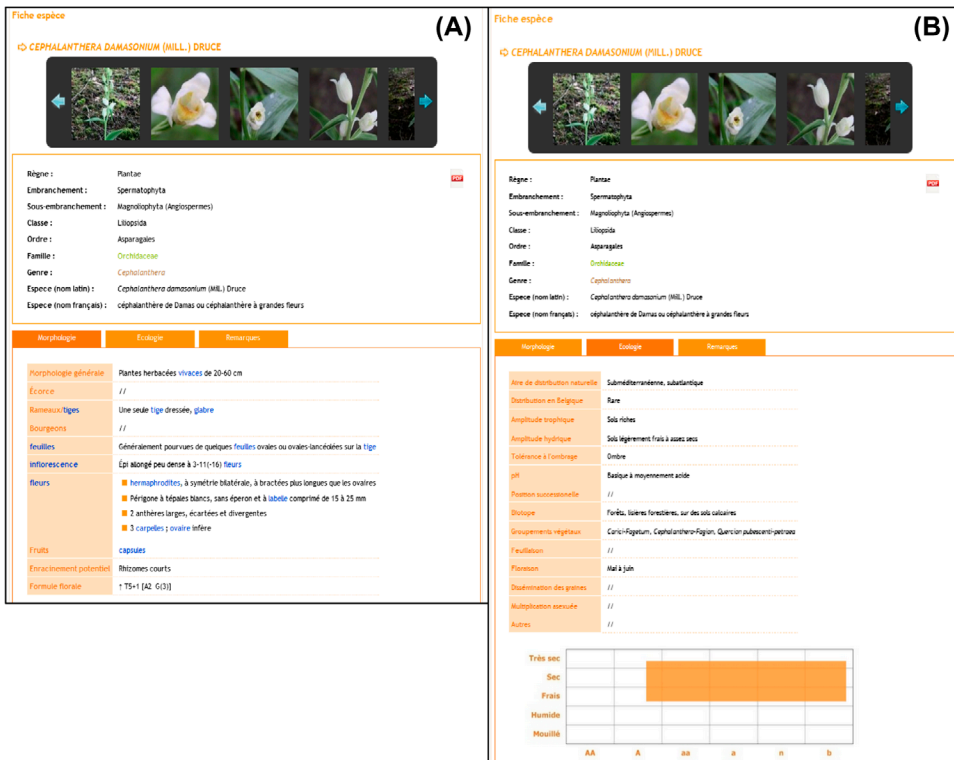

Figure 2.   Description sheet for a species including (A) morphological and (B) ecological characteristics. Words highlighted in blue refer to the illustrated glossary
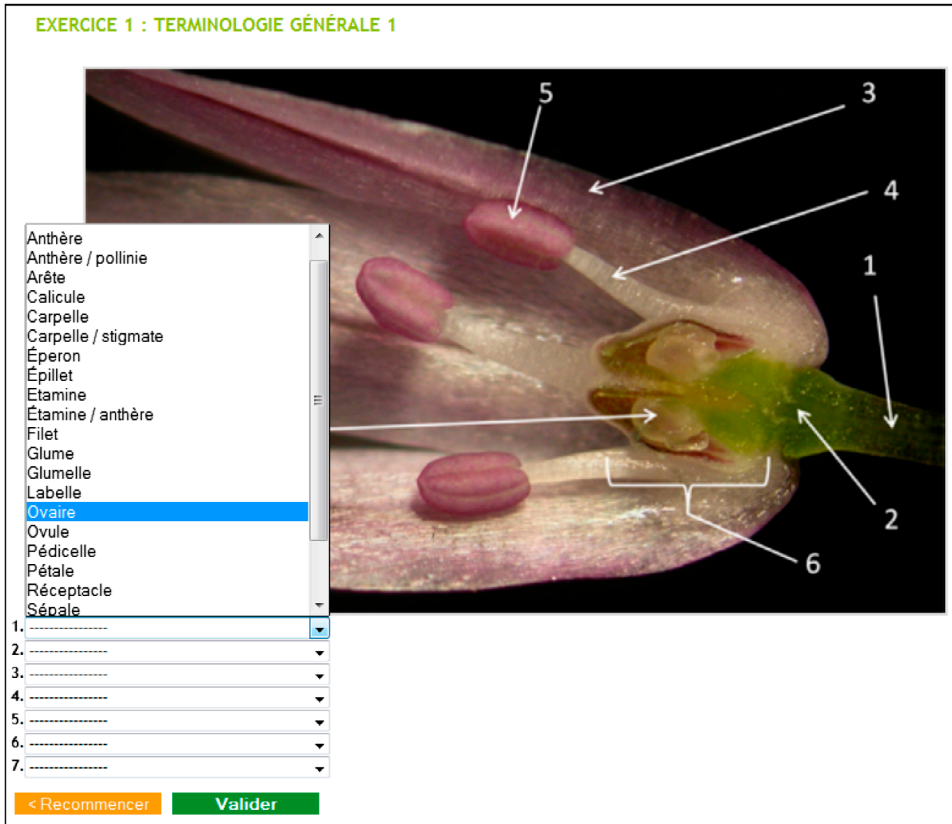
Figure 3.   Quiz to test the knowledge of botanical terms used in floral morphology

Testing the Method

Since the academic year 2014–15, the multimedia tool has been used in a 'Plant systematics' course for undergraduate students (grade 3) in the Faculty of Bioscience Engineering. To check the tool's efficiency in terms of the students' final marks, the total numbers of right answers on the final exam were compared before and after the release of the website (i.e. academic year 2013–14 compared with 2014–15, termed hereafter 2014 vs. 2015). Statistical testing was carried out with R R2.15.1 (R Development Core Team 2012). A significance level of 0.05 was used. Comparison between the exam results in 2014 (without multimedia tool, n = 72 students) and 2015 (using the multimedia tool, n = 63 students) was performed using a Kruskal–Wallis chi-squared test. Data are presented as means ± standard deviation. The exam included a practical portion (75% of the final mark) and a theoretical portion (25% of the final mark). The practical portion included identification of two unknown species, herbarium confection presenting 20 dried flowering plants belonging to 20 different families, and writing a new species information sheet. The theoretical portion included questions about floral diagrams, floral formulas, links between species and

families, a legend of a flower and several definitions (as quiz examples on the web site, Figure 3). The total possible score was 20 points.

Google Analytics was consulted on 2 July 2015 to estimate site user profiles.

Integration with Other Courses

The specific learning goals of the multimedia tool can be achieved independently by users at no charge. However, plant identification needs to be integrated with other competencies, such as dendrology or vegetation surveys, to be professionally relevant. For the students at our university, their activities using the tool are directly connected with face-to-face contact and are clearly integrated in other courses, e.g. as part of field trips, practical tutorials and curriculum mapping. The conception committee for the tool is composed of teachers of related disciplines, and they use the tool during their lectures when appropriate. Thus, this tool constitutes a relevant transversal support for students' education.

Results and Discussion

The results of the exams before and after the release of the website (2014 vs. 2015) are shown in Table 1. The marks were higher in 2015 than in 2014 for both the practical and theoretical portions (Kruskal–Wallis, $p < 0.05$). Students visited the website intensively (Google analytics, consulted on 2 July 2015). During period 1 (January 2015–1 July 2015), 46,205 sessions were registered, with 31,681 users (67% new visitors); also, 233,215 pages were consulted with a mean of 5 pages per session and a minimum of 4 min per session. The number of sessions increased in April and reached a maximum in May and June (450 sessions per day). The majority (75%) was students (18–25 years old). The feedback results showed that students appreciated the tool, as 96% of them reported that the website helped them, mainly to practice plant identification (tool 'identification practice'). They appreciated the web flora (92%) as well as the glossary (97%) and considered the tool to be complementary to field trips and lab exercises (96%) (https://tools.uclouvain.be/limesurvey191/index.php?sid=79,558&lang=fr, n = 48 answers).

Using dichotomous keys and providing extensive practice in plant identification is one way to teach systematics. Having 'fresh' plant material available at any time through

Table 1. Comparison of exam results in 2014 (without multimedia tool) and 2015 (using the multimedia tool) for grade 3 bioengineers, Université catholique de Louvain. Kruskal–Wallis chi-squared (KW) was used for analysis. Data are shown as means ± SD (of a total possible 20 points). N = number of students

Year	Practice	Theory	Total score
2014 (n = 72)	14.8 ± 2.7	12.3 ± 3.6[b]	14.2 ± 1.8[b]
2015 (n = 63)	15.6 ± 2.6	13.6 ± 3.6[a]	15.2 ± 1.9[a]
KW	5.7501	4.8158	7.7490
P value	0.0165	0.0282	0.0054

high-quality photos fosters the development of accurate observation competencies. Upon excluding several members of the same genus or family, a user begins to see genus- or family-level resemblances and eventually develops a concept of this classification level. Knowing the family or genus of an unknown individual can greatly reduce both the time required for identification and the likelihood of error by reducing the number of traits that must be correctly described during the identification process (Kirchoff et al. 2014). Random presentation of flower specimens to be identified enhances the possibility that students will be faced with various practical challenges (Silva et al. 2011).

Identifying species requires not only correct categorisation, but also retrieval of numerous specific botanical terms as well as difficult Latin names. Tasks in which a cue (picture, definition) is presented aid in the recall of the associated target, e.g. the name of the plant. Learning plant identification is therefore similar to other cued recall tasks, such as learning foreign vocabulary words (Kirchoff et al. 2014). Manipulations enhancing cued recall can effectively facilitate learning (Carpenter and De Losch 2005; Sobel, Cepeda and Kapler 2011). Active learning, which requires students to answer test questions, is more efficient than passive learning. In active learning, students interact with the material in some way, rather than reading or viewing without interaction. Active learning has memory benefits even years after the initial learning took place (Pashler et al. 2007). Active learning is especially effective when the correct answer is provided as feedback after an error, as in our interactive dichotomous keys (Marsh et al. 2012).

The effectiveness of multimedia tools for plant interactive keys has already been demonstrated at the high school and university levels in Portugal (Silva et al. 2011). The interactive nature of these keys, with links to a large amount of information, makes it easier and more appealing to teach and learn plant systematics. Moreover, the capacity to introduce additional information allows constant updating, as well as adaptation of the tool for different educational levels. The production of multimedia tools such as interactive dichotomous keys constitutes a simple and effective approach that motivates students and teachers to study plant sciences (Campbell et al. 2011). Similar approaches could be beneficial in other biodiversity/systematics disciplines such as entomology, ornithology and mycology (Randler 2006; Silva et al. 2011).

This multimedia tool was created for undergraduate students, but teachers, and high-school students, as well as amateur botanists can use it to obtain useful information. They can use it, for example, in the field to identify any tree encountered. One long-term objective is to include the complete flora of Belgium, with all herbaceous and woody species. Ultimately, all pages should be translated into both Dutch and English.

Most campus-based universities are moving towards distance education to teach more students with fewer resources. Teaching online courses requires the use of a variety of instructional strategies to enhance interactive learning and provide immediate feedback (Kirchoff et al. 2014). The integration of this multimedia tool into the current programme for students fosters engagement to online instruction. Moreover, our open-source tool can be used by all French-speaking people to practice plant identification online.

In conclusion, more botanical activities at all levels would be highly beneficial for promoting interest in plants (Wandersee and Schussler 2001). This multimedia tool will contribute to this educational task.

Disclosure statement

No potential conflict of interest was reported by the authors.

References

Bastin, B., J. R. De Sloover, C. Evrard, and P. Moens. 2007. *Flore De La Belgique* [Flora of Belgium]. Louvain-la-Neuve: Erasme.

Boullard, B. 1999. *Dictionnaire de botanique* [Dictionary of Botany]. Poitiers: Ellipse.

Campbell, K. R., S. B. Wilson, P. C. Wilson, and Z. He. 2011. "Interactive Online Tools for Teaching Plant Identification." *HortTechnology* 21: 504–508.

Carpenter, S. K., and E. L. De Losch. 2005. "Application of the Testing and Spacing Effects to Name Learning." *Applied Cognitive Psychology* 19: 619–636.

Convention of Biological Diversity. 1996. *Practical Approaches for Capacity Building for Taxonomy*. Report No. UNEP/CBD/SBSTTA/2/5. New York: UN Environmental Program. http://www.cbd.int/convention/.

Flannery, M. C. 2001. "Where is Biology?" *The American Biology Teacher* 63: 442–447.

Kirchoff, B. K., P. F. Delaney, M. Horton, and R. Dellinger-Johnston. 2014. "Optimizing Learning of Scientific Category Knowledge in the Classroom: The Case of Plant Identification." *CBE-Life Sciences Education* 13: 425–436.

Lambinon, J., and F. Verloove. 2012. *Nouvelle Flore De La Belgique, Du G.-D. De Luxembourg, Du Nord De La France Et Des Régions Voisines* [The New Flora of Belgium, Luxembourg, Northern France and Nearby Regions]. Meise: Edition du Jardin botanique de Belgique.

Marsh, E. J., J. P. Lozito, S. Umanath, E. L. Bjork, and R. A. Bjork. 2012. "Using Verification Feedback to Correct Errors Made on a Multiple-Choice Test." *Memory* 20: 645–653.

Pashler, H., D. Rohrer, N. J. Cepeda, and S. K. Carpenter. 2007. "Enhancing Learning and Retarding Forgetting: Choices and Consequences." *Psychonomic Bulletin & Review* 14: 187–193.

Rameau, J. C., D. Mansion, and G. Dumé. 1989. *Flore forestière française. Guide écologique illustré, tome 1 : Plaines et collines* [Forest Flora of France. Illustrated Ecological Guide. Volume 1. Plains and Ills]. Institut pour le développement forestier.

Randler, C. 2006. "Empirical Evaluation of a Dichotomous Key for Amphibian Identification in Pupils and Students." *Journal of Science Education* 7: 34–37.

Randler, C. 2008. "Teaching Species Identification – A Prerequisite for Learning Biodiversity and Understanding Ecology." *Eurasian Journal of Mathematics, Science & Technology Education* 4: 223–231.

R Development Core Team. 2012. *R: A Language and Environment for Statistical Computing*. Vienna: R Foundation for Statistical Computing. http://www.R-project.org.

Schussler, E. E., and L. A. Olzak. 2008. "It's Not Easy Being Green: Student Recall of Plant and Animal Images." *Journal of Biological Education* 42: 112–119.

Silva, H., R. Pinho, L. Lopes, A. J. A. Nogueira, and P. Silveira. 2011. "Illustrated Plant Identification Keys: An Interactive Tool to Learn Botany." *Computers & Education* 56: 969–973.

Sobel, H. S., N. J. Cepeda, and I. V. Kapler. 2011. "Spacing Effects in Real-World Classroom Vocabulary Learning." *Applied Cognitive Psychology* 25: 763–767.

Stagg, B. C., and M. Donkin. 2013. "Teaching Botanical Identification to Adults: Experiences of the UK Participatory Science Project 'Open Air Laboratories'." *Journal of Biological Education* 47: 104–110.

Wandersee, J. H., and E. E. Schussler. 2001. "Toward a Theory of Plant Blindness." *Plant Science Bulletin* 47: 2–9.